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Thorndike Saville, President, A.S.E.E., 1949-50

The newly elected President of the Society, Thorndike Saville, has established an eminent reputation as educator, engineer and administrator. His academic accomplishments include undergraduate work in civil engineering beginning in 1910 at Harvard University and later at Dartmouth College, where he received the Bachelor of Science and Civil Engineering degrees. For two years he was a graduate student in hydraulic and sanitary engineering at M.I.T. and Harvard University, receiving the degree of M.S. from both universities. In 1944, he was awarded the honorary degree of Doctor of Engineering from Clarkson College.

During the first World War he was a 1st Lieutenant in the U. S. Army, where he was in charge of design and partial construction of the Big Bethel Water Supply and Filtration Plant for Langley Field and Fort Monroe. Upon termination of the War, Dean Saville was sent to England and France under a traveling fellowship from Harvard University to study river regulation and sewage treatment processes.

Dean Saville's academic career began in 1919 upon his appointment as Associate Professor and later Professor of Hydraulic and Sanitary Engineering at the University of North Carolina, where he remained until 1932. During this time he served as Chief Engineer of the North Carolina Geological Survey and its successor, the North Carolina Department of Conservation and Development, in charge of the water resources and engineering division.

In 1932 he accepted the post of Professor of Hydraulic and Sanitary Engineering at New York University and subsequently became Associate Dean and Dean of the College of Engineering at that University.

Dean Saville has inaugurated and carried out numerous research projects and has published over 40 articles in technical publications. Among the more important are: (1) "Nature of Color in Water," published as the result of research at Harvard in 1916, which laid the scientific background for several control methods used in water purification processes; (2) "The Cause and Prevention of Red Water Troubles"; (3) "The Water Supply of Caracas, Venezuela," describing the writer's work as Consulting Engineer in that country in 1926; (4) "The Power Situation in the South," published by the American Academy of Political and Social Science in 1931 and describing the past growth and future possibilities of hydro-electric power developments in the southern states; (5) "The Administrative Control of Water Pollution," a detailed study of the problem of investigation of stream pollution by Governmental Agencies in the United States and abroad; (6) "Inventory of Water Resources of the United States," National Resources Board, 1935; (7) "A Study of Methods of Estimating Flood Flows."

His extensive consulting practice includes a Rockefeller Foundation investigation of the water supply for Caracas made for the government of Venezuela; consultant to the U. S. Army Engineer's Board on beach erosion and sand movement; consultant to the U. S. Geological Survey and Mississippi Valley Committee on the investigation of flood frequencies; Executive Engineer of the Water Resources Section of the National Resources Board, and a member of the Water Resources Committee of this Board; consultant to the War Department on the Army Specialized Training Program; a member of the Governor's Technical Advisory Committee of the New York Department of Commerce; member of the National Advisory Committee, Engineering Science and Management

THORNDIKE SAVILLE

War Training Program; advisor on the Public Works Committee of the Hoover Commission on the reorganization of the Federal Executive Departments; Engineer member of the New York State Public Health Council; and a member of the National Advisory Health Council, U. S. Public Health Service.

He has taken a prominent part in activities of the A.S.E.E. as well as other

engineering societies. He was a member of the Council of the American Society for Engineering Education from 1942–45 and was Vice-President in 1948–49. He has also served on the Executive Committee of the E.C.A.C., E.C.R.C., Manpower Committee and numerous other committees of the Society. He has been a director of the American Society of Civil Engineers and President of the Metropolitan Section of that Society. He is a member of the following organizations: American Water Works Association; New England Water Works Association; Boston Society of Civil Engineers; American Institute of Consulting Engineers; American Association for the Advancement of Science, Vice-President (section M) 1943–44; Federation of Sewage Works Associations; American Society of Planning Officials; American Public Health Association; Harvard Engineering Society, President 1947–48; Harvard Club of New York City; Engineers Club of New York, Member Board of Governors 1947–52; Phi Beta Kappa; Sigma Xi; Tau Beta Pi; and the Mayflower Descendants.

Fall Meetings of E.C.A.C., E.C.R.C. and the General Council

The regular Fall Meetings of the Administrative Council and the Research Council will be held in Room 600 of the Kansas City Municipal Auditorium on October 28, 1949. The Morning Session will start at 9:00 A.M. and the Afternoon Session at 2:00 P.M.

There will be a breakfast meeting of the Executive Committee of E.C.R.C. at the Hotel Muehlebach at 8:00 A.M. and an Executive Committee luncheon of E.C.A.C. at 12:30 P.M.

The General Council will have a dinner meeting at the Hotel Muehlebach at 6:00 P.M.

The program for the Engineering College Administrative Council follows:

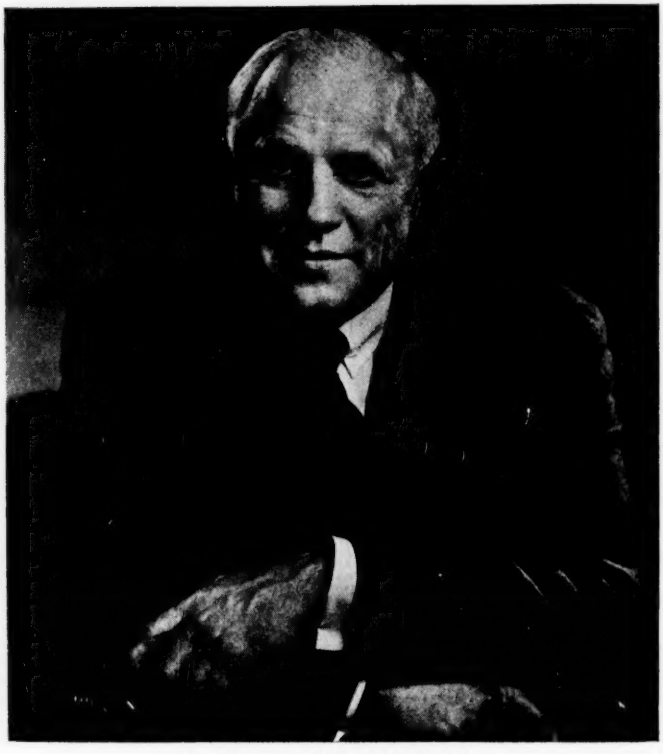
9:00 A.M. Room 600, Kansas City Municipal Auditorium.

1. "Impact of Atomic Problems on Engineering Education"—Dr. L. R. Hafstad, Director of Reactor Development, Atomic Energy Commission.
2. "Opportunities for Engineers in the Field of Nuclear Engineering"—Dr. L. B. Borst, Chairman, Reactor Science and Engineering Department, Brookhaven National Laboratory.
3. "Education for Nuclear Engineering"—Dr. K. H. Kingdon, Assistant Director of the Research Laboratory, in charge of Knolls Atomic Power Laboratory, General Electric Company.
4. "Chemical Engineering and Nuclear Energy Development"—Dr. Stephen Lawroski, Director of Chemical Engineering Division, Argonne Laboratory.
5. "The Environmental Engineering Aspects of Nuclear Activities"—A. E. Gorman, Sanitary Engineer, Atomic Energy Commission.

2:00 P.M. Room 600, Kansas City Municipal Auditorium.
Engineering College Research Council Program.

Room reservations can be made by writing directly to the Hotel Muehlebach and stating that reservation is being made for the American Society for Engineering Education Meeting.

Lamme Award—Karl Taylor Compton



KARL TAYLOR COMPTON

To Karl Taylor Compton for his achievements in scientific and engineering education as a teacher, research worker, administrator and author; for his broad understanding of the relation of education to production and of the engineering college to industry; for his leadership in evaluating staff, equipment and course content in accrediting engineering curricula; for his imaginative insight into the application of science and engineering to the defense of the Nation at war; for his wise counsel to the President of the United States and those in military leadership with him, we award this the twenty-second Lamme Medal.

KARL T. COMPTON was born in Wooster, Ohio, September 14, 1887; his father was a teacher and after graduation from Wooster College he became a teacher, which activity he has continued to this day. In the classroom, the office, the committee room, the commission, the Research Board and the Council of the President he has instructed those who would be taught. His first graduate de-

gree, Sc.M., was taken at Wooster College in 1909 and his Ph.D. was taken at Princeton in 1912. He has been awarded many honorary degrees from many colleges and universities: Doctor of Science, Doctor of Engineering, Doctor of Laws, Doctor of Applied Science, Doctor of Humane Letters. He began his career as an Instructor in Chemistry, College of Wooster in 1909. In 1913 he became Instructor in Physics, Reed College, and then went to Princeton University in 1915. He was Chairman of the Physics Department when he left Princeton to become President of the Massachusetts Institute of Technology in 1930. Dr. Compton was also summer lecturer at the Universities of Michigan, Cornell, Columbia, Chicago, and California. In 1934 he was Pilgrim Trust Lecturer, Royal Society of London.

For a number of years he was consulting physicist for the General Electric Company and for the U. S. Department of Agriculture.

Dr. Compton received the Rumford Medal from the American Academy of Arts and Sciences in 1931 and was awarded the Medal of Merit in 1946. In 1947 he received the Washington Award from the Western Society of Engineers and the Marcellus Hartley Public Welfare Medal of the National Academy of Sciences. He was made Honorary Commander of the Civil Division of the Most Excellent Order of the British Empire, and Commander of the Royal Norwegian Order of St. Olav in 1948.

Dr. Compton is the author of approximately 100 publications dealing with research in photoelectricity, ionization of gases, soft x-rays, spectroscopy in the extreme ultraviolet, fluorescence and dissociation of gases, electric arcs and other types of gas discharge, and other miscellaneous subjects in physics.

He is a member of the following fraternities: Phi Beta Kappa, Alpha Tau Omega, Tau Beta Pi, and Sigma Xi.

Dr. Compton is also a member of the Union and University Clubs of Boston, University Club of New York and Cosmos Club of Washington.

When the accrediting of engineering curricula was undertaken, Dr. Compton was chairman of ECPD's Committee on Engineering Schools. His excellent leadership guided the Committee through the early stages of the work and until the success of the program was assured.

He has been very active in the affairs of the American Society for Engineering Education. He served on the Council, 1933–1936, and from 1937 to 1946; he was Vice President, 1936–1937, and President, 1938–1939.

His work in the War effort was outstanding. His institution was a leader in research and he personally did his part in furthering the research and production of the Nation.

Dr. Compton was appointed by President Truman to succeed Dr. Vannevar Bush as Chairman of the National Military Establishment Research and Development Board, October 15, 1948, bringing to his new duties the benefits of a wide range of experience as scientist, administrator, and public servant.

In order to devote full time to the Research and Development Board, Dr. Compton resigned the presidency of the Massachusetts Institute of Technology, a position which he has held since 1930. He retains his association with the Institute, however, as Chairman of the Corporation.

Dr. Compton is actively interested in the strong impact upon society of technological progress and weapon innovations. In 1940 he was one of a small group of distinguished scientists which called upon the President of the United States and suggested to him the urgency of mobilizing American science to meet the impending threat of war. As a result of these recommendations, the President created by executive order the National Defense Research Committee, and Dr. Compton became one of its original mem-

bers in charge of the division responsible for detection, controls, and instruments. When the Office of Scientific Research and Development was created, the National Defense Research Committee became one of its principal operating arms. Dr. Compton retained his membership on the NDRC throughout the war, and, in addition, became Chief of the Office of Field Service, OSRD, where he directed the program of sending scientific experts into the war theaters to assist in the fullest exploitation of the new weapons which were being issued. His other wartime activities included the following posts: member of the Scientific Intelligence Mission to Japan; member of Secretary of War Special Advisory Committee on the Atomic Bomb; chairman of the United Radar Mission to the United Kingdom; member of the Baruch Rubber Survey Committee; member of the War Resources Board. He was also a member of a Special Committee on Postwar Research appointed by the Secretaries of War and Navy to make recommendations as to the best way of organizing military research in the postwar period.

In 1946, Dr. Compton became a member of the War Department Research Advisory Panel, Chairman of Joint Chiefs of Staff Evaluation Board on Atomic Bomb Tests, and a member of the Naval Research Advisory Committee.

Dr. Compton was appointed Chairman of the President's Advisory Commission on Universal Training which drew up a report on "A Program for National Security" and transmitted it to President Truman on May 29, 1947. In this report international, economic, educational, medical, and religious implications of universal military training were considered. The Commission also studied future kinds of wars and their risks. President Truman, in commending Dr. Compton on his work with the Commission, made the following statement: "The report of the Commission, happily unanimous, will I believe stand for decades to come as a definitive statement of the military policy of the United States."

In the News

In response to the request of those who attended the five Regional Conferences on University Research and Patent Problems in Atlanta, Berkeley, Chicago, Denver and New York, as well as others unable to do so, a summary report on all five conferences is being prepared.

There are approximately 70–75 pages to this report and it is available at $1.00 per copy, which is the cost of printing only. Orders should be sent to Patent Survey, National Research Council, 2101 Constitution Ave., Washington 25, D. C. Checks should be made payable to the National Academy of Sciences.

Dean S. S. Steinberg of the **University of Maryland** College of Engineering attended the First Pan-American Congress held in Rio de Janeiro, Brazil, July 15 to 24, as a guest of honor of the Congress. Dean Steinberg was Chairman of the United States Engineering Delegation of 40 engineers who attended the meeting.

Preceding the Rio Congress, there was held at Sao Paulo, June 9 to 13, a meeting of engineers representing all the countries of the western hemisphere to organize a Pan-American Union of Engineering Societies. In 1945 and in 1948, under the auspices of the Department of State, Dean Steinberg visited all 20 Latin-American republics on a survey of engineering and engineering education.

George Westinghouse Award—Joseph Marin

JOSEPH MARIN

To Joseph Marin for his effective contributions to the training of graduate and undergraduate students in the field of applied mechanics; for his important contributions, through research, to knowledge of the applications of principles of mechanics to the uses of engineering materials; for his many scientific and technical articles which have brought the results of experimental researches into reach of practicing engineers; and for his painstaking efforts to develop better teaching materials in the form of textbooks, class notes, problems, and laboratory equipment.

The engineering profession is proud to acknowledge its debt to Joseph Marin. As an indefatigable research worker, as an enthusiastic and inspiring teacher, as a practicing engineer and consultant, and as an active member of professional societies, his services to the field of theoretical and applied mechanics have been manifold. Through his scientific papers he has made many important contributions to the knowledge of mechanical properties of materials and to the principles of stress analysis. He has assisted materially in bringing to the practicing engineer and designer some of the latest theoretical and experimental developments in engineering mechanics.

Although born in New York City on June 7, 1905, Dr. Marin spent most of his early years in Canada and received his Bachelor of Science degree in Civil Engineering from the University of British Columbia. His subsequent graduate work was carried on at the University of Illinois and as a pupil of Professor Stephen Timoshenko at the University of Michigan, where he was awarded the degree of Doctor of Philosophy in 1936. Dr. Marin served as Instructor in Civil Engineering at Rutgers University from 1930 to 1934 and at the same institution as Assistant Professor of Engineering Materials from 1934 to 1939. In 1939 he became Associate Professor of Civil Engineering at Illinois Institute of Technology. In 1942 he was appointed to his present Professorship of Engineering Mechanics at Pennsylvania State College.

Throughout his teaching career, Dr. Marin has contributed to the improvement of instruction of both undergraduate and graduate students. He is the author of several textbooks; he has prepared class notes for many graduate courses; and he has shown ingenuity in devising specialized laboratory equipment for instructional and research purposes. He has also continued to serve as an inspiring teacher to many engineers in the non-academic world by contributing clear and concise presentations of design solutions to various scientific and technical journals.

Doctor Marin was engaged in research and developmental work in the Turbine Division of the Westinghouse Electric and Manufacturing Company during 1937, and has been employed as consultant on stress analysis problems by the Curtiss-Wright Corporation and other companies since the beginning of the War.

He has directed numerous important research investigations in the mechanical properties of materials. Among the organizations for which he has carried on research projects are National Advisory Committee for Aeronautics, Welding Research Council, Wright Field, and Office of Naval Research. He is a member of the Executive Committee of the Society for Experimental Stress Analysis, an active member of many professional society committees, and maintains membership in American Society for Engineering Education, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society for Testing Materials, Society for Experimental Stress Analysis, Institute of Aeronautical Sciences, Sigma Xi, Phi Kappa Phi, Tau Beta Pi, and Chi Epsilon.

Professor and Mrs. Marin, the former Jean Brunton, whom he married in 1939, reside at Boalsburg, Pennsylvania.

Sections and Branches

The **Illinois-Indiana Section** members of the American Society for Engineering Education held their annual meeting on the campus of the University of Notre Dame on Saturday, May 14, 1949. The meeting was called to order at 10:00 A.M. and the group was addressed by the Reverend John J. Cavanaugh, C.S.C., President of the University of Notre Dame, by Dean Karl E. Schoenherr of Notre Dame, and by Harold S. Vance, President and Chairman of the Board, The Studebaker Corporation. Many of those attending the meeting took advantage of the conducted campus tour just before luncheon which was served at 12:45. The afternoon program consisted of seven technical sessions.

Program for the Year

By THORNDIKE SAVILLE

President of the ASEE and
Dean of Engineering, New York University

During the war years engineering colleges were confronted with numerous special training programs, a severe drop in normal student enrollment, and the departure of many faculty members for military and other national service. Quite naturally Society activities were markedly reduced, and those in effect were strongly colored by considerations of the national emergency. Recovery from the war posed still other new problems, and it has been only during the past year that some semblance of normality has returned. During that year the Society has been reinvigorated under the vigorous leadership of my predecessor Dean C. J. Freund. The officers have been stimulated to action in the realm of Society affairs for which they are respectively responsible, old committees have been reactivated and important new committees established, and the membership at large have evidenced a determination to make the Society function effectively in all of the areas contemplated by the Constitution. Indeed the Constitution itself has been revised.

All of this is most promising for the future. The Society is definitely not static. Many new members have been added to our rolls, and look to the Society for guidance, information, and as a medium for the exchange of new ideas relating to the many phases of engineering education. It is my purpose to help consolidate the progress which we have made, to try to keep our new activities and experiments within the limits of effective action, and to endeavor to make the influence of a Society of some 6500 professional engineering educators not only a constructive force in higher education, but an influence which should be brought to bear more effectively on national affairs.

The engineer presently occupies a higher place in public esteem than ever before. One may well argue that this is due in no small measure to the improvement in the character and scope of his professional education over the past twenty-five years. I believe this is an achievement of our Society membership, acting individually and collectively. But, preoccupied with our primary obligations to recruit new and competent faculties, to revise curricula, to meet new advances in science and technology, to improve the methods and aims of instruction, and to analyze the trends of employment and salaries as affecting our occupation, we have perhaps neglected to exert adequately our influence and prestige in social and economic matters affecting both the profession and the national welfare.

During the past year major efforts were made to improve relations with industry. An effective committee made dramatic strides in this direction, as evidenced by the program at our last convention. These gains should be consolidated and pursued further. On the other hand, we must not neglect that other area of engineering employment—the government services on all levels—federal, state, and local, long the chief outlet for civil engineers. The trends of the times clearly indicate a great increase in employment of all types of engineers in government activities. I hope during the

ensuing year that we may begin to formalize our relations in this field.

Perhaps never before in the history of the Society have we so many new and relatively inexperienced teachers on our faculties. We must bring to them, and to our older members too, some guidance as to effective teaching. The straight mechanics of good teaching have been neglected, and I look to the new committee suggested by Dean Hammond, and of which our Westinghouse Award winner, Dr. Teare, is Chairman, to begin an attack on all of the facets of this vitally important subject.

Wholly justified complaints have come in increasing volume the past two years from both our younger members and from certain of our ablest teachers, to the effect that our Divisions, Committees, and Councils are on the one hand concerned too greatly with topics of administration or research, and on the other hand that conferences at our annual convention tend to be monopolized by the views and papers of the older and more distinguished members. The younger and quieter men find little opportunity to be heard, and the papers too frequently represent individual views rather than fully considered group opinion.

President Freund and I collaborated last year in establishing a "young man's committee" to be restricted to those of instructor or assistant professor grade and under 30 years of age. Professor Frank L. Schwartz of the University of Michigan is Chairman of this committee. Its usefulness to younger members will depend solely upon the ideas they convey and the extent to which they participate in its activities. The formulation of problems for group study and report by the several Divisions and Committees was urged by me a year ago. Such projects when presented to the conferences will provide opportunity for constructive discussion, and will correlate importantly with the program of Dr. Teare's new committee.

The relation of junior and community colleges, and of technical institutes to the general problem of engineering education is increasingly important. The programs of our strong committees on these subjects merit the active participation of more of our members.

A scrutiny of our many Divisions and Committees in the Year Book, which I urge upon every member, shows ample opportunity for each member to participate actively and constructively in one or more of the intriguing aspects of engineering education. Only by such participation by a majority of our members can the Society remain alert, progressive, and useful. I regard my primary obligation to be concerned with the Society *as a whole,* and to that end I seek not only suggestions from officers and from Divisions and Committees, but from the membership at large. Will you not express to me or to other officers your thoughts as to what we should do and how we should do it, however radical or visionary they may appear? Only by ideas properly implemented may the Society effectively achieve its goals.

Coming in the October Journal . . .

A new feature, "Letters to the Editor." Letters, not exceeding 250 words, should be sent to the Office of the Secretary.

Engineering Education and Freedom from Fear*

By C. J. FREUND

Retiring President of ASEE and Dean of Engineering, University of Detroit

To be afraid of the atomic bomb is possibly the most common experience of people who live in civilized countries, except for concern to procure food, clothing and shelter. And when they can get the atomic bomb out of their minds, the people are tormented by reports of supersonic planes, guided missiles and biological inventions for the destruction of all animal and vegetable life over miles of countryside.

We are used to thinking about technological weapons only as they are utilized in warfare. But burglars, murderers and other criminals may likewise take advantage of the new technologies. Indeed, criminals have long used firearms, explosives, gas cutters and automobiles. People are not afraid of engineers, thank goodness, but they are excessively afraid of much that engineers contrive.

The engineer has mastery over the life and death of his fellow men. Hence it is of tremendous consequence that he shall have a keen sense of the difference between right and wrong. Engineers in Nazi Germany discarded their moral codes, or never had any, and we know what horrors resulted. A writer in the *New York Times* for February 28 of last year stated that "if Hitler, Goering, Bormann and the rest were the greatest criminals of the modern world, it is not because they were themselves supermen. . . . It is because they were obeyed by thousands of first class administrators and technicians who were politically neutral." Surely there is no greater menace in the world than a superbly competent engineer who is equally content to engage himself to a benefactor of the human race, or to some monster of cruelty and vice.

Responsibility for Moral Training

American engineers have generally been moral. But have we any right to assume that they always will be moral? Eminent thinkers have some misgivings in the matter. The impressive deliberations at the Massachusetts Institute of Technology three months ago, again and again shifted to the question of the moral responsibility of engineers and scientists.

Whose responsibility is it to make sure that engineers shall continue to be moral? It is difficult to impart to our students a sense of right and wrong, and we engineering educators might be tempted to consign the task to parents, pastors and school-teachers. However, we have already accepted a share of the responsibility. The Committee on Aims and Scope of Engineering Curricula of our Society reported that a major objective of engineering education shall be to develop "moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude."[1] We adopted that report in our annual meeting at the University of California in 1940. We must either repudiate that portion of the committee's report or make it our business to graduate moral engineers.

We must confess, I am afraid, that our actual accomplishments in the moral training of our students have been pretty meager. Except for an occasional endorsement of the Golden Rule we have little to show. If our engineers have been moral, it has not been particularly

* Presidential address presented at the Annual Meeting of the ASEE, June 21, 1949.

[1] JOURNAL OF ENGINEERING EDUCATION, Vol. 30, March, 1940, p. 564.

because we made them so. To quote Mr. C. E. Wilson in his February address before the American Institute of Electrical Engineers, "It is one of those strange quirks of human nature that most men are not at all embarassed or reluctant to discuss with their fellows the day-to-day technical and professional problems on which they are engaged; but the more their minds run to shop talk on any plane, the more tongue-tied and thought-tied they become when a general question of morals or human behavior is posed." [2] We understand the principles of science and of engineering, and we teach these principles to our students. But we do not teach moral principles, and I have a guilty feeling that we don't even know just what those moral principles are.

We all agree that we must impart moral insight to our students. But how shall we go about it?

Religion

It is my personal and deep conviction that we can finally and completely solve the problem of moral training only by religion. Apparently, I am by no means alone in this conviction. 95 per cent of the American people believe in God, according to a survey completed late last year.[3] As I get to know more of them, and to know them better, I find that many of our Society members are also church members. In the war years, when the annual meetings of our Society were held over week ends, the programs often featured religious services on Sunday morning. Engineering students at Princeton are registered for elective courses in religion. The University of Michigan has been planning for some years to institute a school of religion. Yale University has restored religion to an important position in the fabric of departments and courses. A year ago, in his address on the occasion of the inauguration of the president of the Case Institute of Technology, James Mooney asserted that "the engineer must recognize moral and spiritual values in life in order to have a sympathetic understanding of his fellow men. It is here that religion can do its part in making the engineer a full man." [4] And in "Human Destiny," Lecomte du Noüy declares that "if we have read the signs of the times correctly, or even if we have exaggerated some of the symptoms, the only salvation for mankind will be found in religion." [5]

Possibly I should explain that when I propose religion as the ultimate and complete solution of our problem, I do not mean the teaching of religion as an interesting field of knowledge by teachers who may themselves be altogether irreligious persons; I do mean the teaching of that very kind of dogmatic religion which so many intellectuals despise.

Of course, it is not feasible to teach religion in most of our colleges and schools of engineering, for good and sufficient reasons which we need not go into this morning. The great majority of us must get our students to know right from wrong by some expedient other than religion. What other expedients are there?

Ethics

Can we not teach ethics, the branch of philosophy—not of religion—which has to do with moral principles and moral deportment? Or rather, can we not plan to teach ethics? We cannot teach ethics immediately in all our schools because, for one thing, there are not enough qualified teachers.

Engineering educators are practical men; many of them will shrink from so abstract and intangible a subject as phi-

[2] "The Professional Estate," by C. E. Wilson, presented at a meeting of the American Institute of Electrical Engineers, Hotel Statler, New York City, February 2, 1949.

[3] "God and the American People," *Ladies' Home Journal*, Vol. 65, November, 1948, p. 37, *passim*.

[4] "Industry Considers the Scientist and Engineer in Public Affairs," *Society's Challenge to Technical Education*, Case Institute of Technology, Cleveland, Ohio, p. 14.

[5] P. 264.

losophy. They will ask, "What do you mean by ethics; what, precisely, shall we teach?" Resources of ethical subject matter are available to us. Great thinkers and teachers in all ages have announced principles and have evolved codes of ethics, and the civilized nations have accepted these principles and codes; or at least those nations which C. E. Wilson calls the God-fearing nations as contrasted with the God-hating nations.

Winston Churchill was talking about the principles and codes of ethics at the Massachusetts Institute of Technology when he spoke of "our inheritance of well-founded, slowly conceived codes of honor, morals and manners, the passionate convictions which so many hundreds of millions share together of the principles of freedom and justice. . . ." From the codes of ethics evolved over the ages, can we not extract condensed and simplified systems, and teach these systems in the schools of engineering? Can we not construct our subject matter upon the natural law, and upon the essential nature of man, his rights and obligations, and the rights and obligations of the family, the community and the state?

And in the business of putting together subject matter, can we not be guided by conscience, the instinctive faculty whereby we judge between right and wrong, even when we fail to act according to our judgment? Every day, every hour of our lives, we praise or blame some person or some influence, or we approve or disapprove some action. Conscience is almost always the basis of these spontaneous determinations?

Now, where shall we look for statements of ethical principles and codes? We may doubtless find most of what we need in the works of philosophers and moralists of the civilized nations: Aristotle, the Stoics, Cicero, Augustine, Thomas Aquinas and many others who have proclaimed the natural law. Moreover, may we not obtain valuable data from the writings of Jefferson, Franklin and other intellectuals and political economists of early America? These thinkers and authors recorded the sturdy moral code of their time. This code is possibly our finest distinctively American heritage, and may be responsible to a large degree for American prosperity and well-being.

You may ask, "Why explore in former ages? This is a new and a thrilling era; why not strike out for ourselves?" It is seldom prudent to discard experience. Why should we begin all over again? We don't in science and in engineering. Why should we rack our brains over problems which others have already solved? Why should we become entangled in perplexities which our predecessors have already unravelled? To quote again from James Mooney's Case Institute address, "Probably the gravest obstacle at present is a form of mental disease which seems to have spread throughout our country: some outgrowth of our trying to be too smart, a flaunting of all previous experience, a presumption that the experiences of the generations before us with similar problems are worth nothing. . . ."[6] Mr. Mooney's protest is especially appropriate because morality pertains to human nature, and human nature has not changed throughout the centuries.

It is reassuring, and to be expected, that the great philosophers of the civilized nations are agreed with respect to morality; or at least they agree in matters of everyday life: that men should tell the truth, respect the persons and property of others, obey the laws of the land. We have always accepted uniform and consistent opinion and experience as reliable standards and guides. Principles and codes of ethics have resulted from twenty-five hundred or more years of close observation of human deportment, and of concentrated thinking about such deportment, and the nature of man, by the keenest and the noblest minds.

Teaching Methods

So much for the subject matter of ethics. How to teach ethics may be

[6] *Op. cit.*, p. 11.

nearly as important as the subject matter. Presumably, we seek to acomplish two main objectives: (a) that our students shall master ethical principles and codes; (b) that they shall live and act according to these principles and codes.

If the student is to master principles and codes, the instructor must not only recite them, he must clarify them by abundant and graphic illustrations. It may be difficult to work up case material, but it can be done. The classes may study questions of professional ethics which have been argued before and recorded by the state boards for engineering registration. Some years ago, the editors of *Civil Engineering* submitted a problem in professional ethics in each of successive issues over many months; and in each succeeding issue, Professor Daniel Mead proposed a solution of the preceding month's problem. The purpose of the series was to clarify the relations of engineers with clients and employers, and with one another. Should not the instructor be able to prepare similar cases to illustrate those broader questions of general ethics which have to do with the relations of the engineer, as citizen, to the whole community?

And then there is the business of motivation. Unfortunately, you cannot make people behave by educating them. It has often been asserted, but none of us has ever seen it proved, that vice goes hand in hand with ignorance and virtue with enlightenment. Nothing will be gained if the engineering student discourses brilliantly on ethical principles and codes, and violates all of them after he graduates.

The instructor will certainly have to appeal to the known ideals and attitudes of young men. Students are hero worshippers; they look up to those who are strong and virile, and they are inspired by loyalty and integrity, and a willingness—even eagerness—to fight for what is right. The instructor will need so to represent ethical principles and codes as to make them appeal to the students. Besides, he will have to be the type whom students respect and admire. And he will obviously have to be moral and ethical himself, although he will need to be adroit about it, because it is socially quite impossible for anyone formally to set himself up as a model of good behavior.

Auxiliary Devices

The engineering faculty can be of great help to the teacher of ethics by promoting and encouraging student government associations, honor systems, religious foundations and other character building extra-curricular student activities. And they can vigorously support and defend the teacher of ethics, his teaching and his project, whenever and if ever they are challenged.

And when a school or college has adopted principles and codes of ethics for instruction, why should not each student be required to sign an endorsement of the principles and codes as a requirement for the degree; or still better, for promotion to junior standing? This would not be an airtight precaution, of course, because a few dishonest students would doubtless not hesitate to falsify the endorsement. However, many undesirable students would never even apply for admission to an institution in which such a "preposterous" requirement were imposed, and both students and the public would clearly see that the school means business.

None of us would hesitate to expel a student for thievery, conviction of felony or for any serious violation of good deportment. Why, then, should we train an immoral person in the potentially dangerous skills of applied science? Who of us wants to be responsible for turning out into the world a vicious or immoral man whom we have made proficient in the arts and sciences of engineering?

Conflict of Viewpoint

I realize, of course, that I may be out of line with certain prevailing viewpoints. It is the fashion of the moment to contend that knowledge can result only from the inductive method, from quantitative

research. The typical modern intellectual contemptuously rejects everything which cannot be proved in the laboratory or by laboratory methods. From this he concludes either one or the other of the following propositions:

(a) That even moral standards can be developed only in the laboratory, or by laboratory methods;
(b) That morality does not exist; that there is no such thing as right or wrong.

Sometimes I wonder about some of these modern intellectuals. I am thinking about a distinguished professor of sociology in one of our great universities. On a Friday morning he told his lecture class that morality is a fiction, a medieval superstition. On that Saturday afternoon he cultivated his garden and got into a quarrel with his neighbor on the other side of the fence. As the quarrel accelerated, the neighbor called the professor immoral. That made the professor very angry. He vaulted over the fence and soundly thrashed his neighbor.

The modern intellectual vigorously condemns the teaching of right and wrong because morality has not been established by experimental research, and hence, must be arbitrary and dogmatic.

But the modern intellectual subscribes to the doctrines of the Declaration of Independence and of the Preamble to the Constitution of the United States, which doctrines have not been proved by experimental research.

The modern intellectual talks enthusiastically about democratic institutions; and sometimes about free enterprise and private property; and he can't prove any of them by experimental research.

The modern intellectual is horrified by concentration camps; but he can't prove by experimental research that they are not altogether proper.

"Unless it comes out of the laboratory or is based on experiment, it is unproved dogma," proclaims the modern intellectual. But he can never prove this proclamation in the laboratory; hence his very proclamation is unproved dogma, according to his own definition. At one and the same time the modern intellectual renounces dogma and promulgates a notorious dogma. What a masterpiece of contradiction!

Methods of Experimental Science Not Appropriate in Moral Questions

On the other hand, if the modern intellectual asserts that moral standards can be developed by experimental research, he clashes with well known authorities whom we engineering educators regard very highly. For instance:

S.P.E.E. Committee on Engineering Education After the War:

"The natural detachment so desirable in science will not suffice . . . where concepts of value and motivation of social conduct are involved."[7]

A.S.E.E. Committee on Academic Tenure, Professional Service and Responsibility:

"The physical sciences have been exceedingly fruitful in engineering technology; so far they have been equally sterile in the technology of human conduct."[8]

Edmund W. Sinnott:

"To many it (application of science) seems the only road which it is safe to follow. But there is a wide terrain into which this newest highway of the mind can never penetrate, a country where are found the rich facts of experience—subjective, primary, immediate; our emotions, desires, purposes, values, feelings of beauty and ugliness, of right and wrong, of love and hate."[9]

Arthur Compton:

"Yet it is a narrow view to say that we should live only by that which can be subjected to scientific tests."[10]

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[7] JOURNAL OF ENGINEERING EDUCATION, Vol. 34, May, 1944, p. 595.

[8] JOURNAL OF ENGINEERING EDUCATION, Vol. 36, June, 1946, p. 610.

[9] *Mechanical Engineering*, Vol. 70, February, 1948, p. 115.

[10] "Why I Believe in Immortality," *This Week*, April 12, 1936, p. 12.

Irving Langmuir:

"... similar difficulties are found in all social problems, for their complexity is almost infinite compared to that of typical physical phenomena, and the ability to choose desirable experimental conditions and to repeat the experiment as often as desired is wholly absent." [11]

J. R. Oppenheimer:

"Science is novelty and change. . . . These qualities constitute a way of life which of course does not make wise men from foolish, or good men from wicked." [12]

Experimental research just won't work in moral investigations. A psychologist or a sociologist may observe the actions of a great many people in the most perfectly organized and the most carefully controlled experiments extending over a year or a decade. And when he has finished what does he have? He may have a conclusion indicating what people do or will do under a given set of conditions. But he can continue his experiments for countless years on end, and he will never discover what people *ought* to do; and what people ought to do is the object of morality.

Experimental research cannot be challenged in the physical sciences, and may be useful as an auxiliary device in the study of ethics. But if we are to create or to reinforce in our students a keen moral judgment, a rugged sense of right and wrong, shall we not have to indoctrinate them with principles which we have learned from philosophers and teachers who are the recognized guides of civilized peoples—and have been for twenty-five hundred years?

And if a change of policy could, in time, permit the teaching of revealed religion, so much the better.

Freedom from Fear

Engineering educators have accomplished difficult tasks in the past. Perhaps they can now undertake that hardest of all projects, the training of successive generations of highly moral engineers. If they succeed, the peoples of the world can be assured that the engineer will not prostitute his skills to the vicious designs of criminals or rascal dictators. And a reasonable hope for freedom from fear may be restored!

[11] "Science as a Guide in Life," *General Electric Review* (Reprint), Vol. 37, July, 1934, p. 6.

[12] Quotation in "The Scientists," *Fortune*, Vol. 38, October, 1948, p. 173.

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College Notes

The appointment of Charles N. Gaylord as chairman of the Department of Civil Engineering at the **University of Delaware** was announced today by Dean David L. Arm of the University's School of Engineering. Mr. Gaylord replaces J. W. Shields, who has resigned to become assistant general manager of the South Carolina Public Service Authority. With the rank of professor, Mr. Gaylord will assume his duties at Newark on Sept. 1. He has been professor of structural engineering, and assistant dean of the College of Engineering, at the University of Alabama.

Lee S. Whitson, chief industrial engineer at the Minnesota Mining and Manufacturing Company, St. Paul, was appointed professor of mechanical engineering at the **University of Minnesota.** Whitson will be in charge of the section of industrial engineering in the institute of technology.

J. Eldred Hedrick of New York City, senior technologist of the Shell Chemical Corporation, has been appointed a professor of chemical engineering at **Cornell University.** He will join the staff of Cornell's School of Chemical and Metallurgical Engineering this month.

Dr. Rolf Eliassen has been appointed professor of sanitary engineering in the department of civil engineering at the **Massachusetts Institute of Technology.** Dr. Eliassen, who assumed his duties at M.I.T. on July 1, will be in charge of the work in sanitary engineering at the Institute. This includes the graduate course in sanitary engineering as well as extensive undergraduate work in the field given within the civil engineering course. Dr. Eliassen will also supervise a research program in the analysis, purification, and disposal of industrial wastes, as well as studies in water supply contamination and purification.

Edward F. Degering, professor of chemistry and director of industrial research projects at Purdue University, has been named assistant chairman of chemistry and chemical engineering research at **Armour Research Foundation** of Illinois Institute of Technology.

Report of the Vice-President in Charge of General and Regional Activities

The activities of your Vice-President in charge of General and Regional Activities and his Committee on Sections and Branches may be divided into three general headings.

1. The general membership and its relation to Sections and Branches.
2. Section activities.
3. Branch activities.

General Membership

The map showing the geographical distribution of Sections and published in the JOURNAL for February, 1948 was developed to show the location of every faculty member or group of faculty members belonging to the A.S.E.E. In this way it was possible to determine the Branch or Section nearest to each of these members or groups.

This work was carried on in the belief that the strength of the Society lies in the interest of individual members and that the interest of the individual members is greatly affected by their activity in the Society. The member may be ever so philosophic in his attitude; he may retain a life-long membership because of the great service to engineering education rendered by the Society; but he will really be enthusiastic when he is able to take an active part in Society affairs. Then he begins to encourage his colleagues to join and become active and shortly the Society begins to feel the effect of increased interest and growth.

Wherever the map and our records indicated that there was a possibility that a member or group of members were not attending or were not associated with a Branch or Section of the Society, a letter was written to the individual or group asking whether they were attending the Branch or Section meetings nearest them geographically and calling attention to the calendar of Section meetings now being printed in each issue of the JOURNAL. Many replies were received, some of them apologizing for their lack of interest and promising to make an attempt to attend the Section meetings near them, while others indicated that their attention had never been called to the existence of a Section or Branch near them.

Section Activities

In our correspondence with the officers of Sections and Branches we encouraged the submission of suggestions for improvement in Society operation. A request was voiced from several sources that more attention be paid to the problems involved in teaching with less emphasis on problems of administration. This request applied to both Section meetings and the annual meeting of the Society. A letter requesting information was sent to the Sections inquiring about the type of program they were accustomed to prepare for Section meetings. Most Sections meet but once a year and an analysis made of programs from eleven Sections indicate that last year about thirty per cent of the time was spent discussing teaching techniques, and thirty per cent discussing curricula. Reports were obtained from only about two-thirds of the total Sections so the picture is not complete. There is, however, considerable variation in the programs of the various sections. Where the meetings included special groups of the various engineering divisions, such as civil engineering, draw-

ing, electrical engineering, etc., more time was spent on teaching techniques and round table discussions. It is suggested that some thought be given to this problem in case of future general programs for the national meetings.

Geographical extension of some sections has taken place to include schools that were formerly not affiliated with any Section. The North Midwest Section added the University of North Dakota, North Dakota State College, and South Dakota State College with the provision that these three schools are to act jointly in entertaining the North Midwest Section when it meets in their locality.

The Missouri Section has added the University of Arkansas, and the Rocky Mountain Section the University of Utah and Utah Agricultural College. There has been considerable discussion in the past few years on the formation of Sections of the Society in Canada. However, the schools are far apart and are often nearer a Section in the United States than to each other. The suggestion was made by the New England Section that Canadian schools in the Maritime Provinces be invited to join that Section. However, it appears at the present time, that the national conference of Canadian Universities has a Committee on Applied Science and Engineering Education. In order to avoid any misunderstanding, President Freund has written that committee and the matter will be discussed at their meeting in June of this year. The National Capital Section which became dormant because of other activities during the war has been reorganized through the efforts of Vice-President Steinberg and others. A new constitution and by-laws have been adopted and the name is changed to the National Capital Area Section.

There is still much to be done to make our Section organizations more effective. This is particularly true where the Section covers a large geographical area or where the terrain makes travel difficult. For example, the Pacific Northwest Section meets alternately on the East or on the West of the Cascade Mountains, and finds considerable difficulty in securing attendance when the meetings are held in a Montana school. Because their school problems are of similar nature the Montana schools prefer to belong to the Pacific Northwest Section.

Branch Activities

Correspondence with schools where there are organized branches of the A.S.E.E. indicates that they are extremely useful. Yet, there are only twenty-two such organizations in the United States. One Dean writes, "Having a branch means that your group is organized and whenever a concerted effort is needed the organization is in existence."

Meetings of the local branch are excellent mediums for discussions of teaching methods and techniques, relations between faculty and students, roads to success for young men entering the teaching profession, etc., etc. It is a good place to invite authorities on educational methods, our friends from the other colleges, practicing engineers, and employers to talk with us.

Where branches have been established, the local membership has increased, attendance at the section meetings has grown, and interest in the work of the National Organization and its objectives has been stimulated. After all, the A.S.E.E. is the only Society of national scope devoted exclusively to the profession of teaching engineering. As such, it is perhaps the most important agency through which engineering educators may express themselves. It is recognized by all state and national organizations and agencies.

Besides, the local branch is a good place to give rising young men a chance to develop leadership. Some of them should be elected to branch offices.

The Committee on Sections and Branches and the Executive Board believe that the activities of the present Branches exert an important influence on the development of engineering education and the future of the Society.

Letters received indicate that there are some extremely active Branch organizations. Very interesting and enthusiastic reports have been received from Michigan State College Branch, the Branch at the Michigan College of Mining and Technology, the Branch at North Carolina State College, the University of Washington Branch and others. As an example of the growth of membership, the University of Washington Branch started with thirteen members and now has fifty-three.

The Branch at the University of Alabama has organized a permanent committee on "Cooperation with Industry." They have been working with the Associated Industries of Alabama and members of this organization attended the A.S.E.E. Branch meetings. Later the Associated Industries entertained members of the University of Alabama Branch as guests at a panel discussion held in Birmingham.

The Minnesota Branch, in connection with the "Partnership with Industry" program of the National Society, conducted a three-day symposium on Industrial Engineering research, at the Center for Continuation Study. Nationally known speakers addressed the symposium which was attended by nearly 100 educators and representatives of industry. The program was planned by a joint committee of local industries and the A.S.E.E. and was financed by charging a registration fee of $8.00 for each person in attendance.

Because of enthusiastic reports from active Branches the Committee started a preliminary investigation to determine the attitude of schools toward Branch organizations. Schools with twenty-five or more members were contacted. From replies received, it appears that Branches could be organized in many schools to good advantage. This is particularly true where the geographical area of the nearest Section is large, and Section meetings are held only about once a year. Where the Section is small geographically and Section meetings can be held more frequently, Branch meetings seem to have little value. Although the replies were unanimous in agreeing that Branch activities were desirable from the standpoint of the local school and the Society itself, many schools reported that they were already over-organized and burdened with multiplicity of meetings of various kinds of engineering Societies and campus organizations. A successful Branch must have energetic backing and this cannot be expected where the faculty are already plagued by too many meetings. It is believed, however, that it would be very much worthwhile to encourage the establishment of Branches in localities where they can operate to advantage, and that much more can be done by organizing a limited number of Branches in suitable locations than by attempting a campaign of national scope for an increase in Branches of the Society.

Respectfully submitted,

B. J. ROBERTSON, *Vice President in charge of General and Regional Activities and Professor of Mechanical Engineering, University of Minnesota*

June 10, 1949

Report of the Vice-President in Charge of Divisions and Committees for the Year 1948–49

Contact was continued during the year with all of the Divisions and Committees by means of two circular letters. The first pointed out the necessity for early programming of papers for the annual meeting, and the desirability of undertaking a certain number of long term projects by groups in the several Divisions and Committees which would result in group reports rather than in individual opinions. The second called attention to the desirability of increased collaboration with the Research Council in connection with research papers stimulated through the Divisions and Committees, and the possibility of certain joint sessions between Divisions and Committees and the Research Council.

A considerable amount of time was given to the stimulation of the Junior College Committee, together with its program and the initiation of a joint session with the Technical Institute Committee.

A policy with respect to summer schools was considered, and will be further amplified during the ensuing year. It is probable that a letter expressing the Society's general policy with respect to summer schools will be developed and sent to all Divisions and Committees, with a report to the next Vice-President in charge of this work.

A new committee was inaugurated under the chairmanship of Professor Schwartz to sponsor the interests of the younger men, membership in the committee to be restricted to those of assistant professor rank or less, and under 35 years old.

A letter was directed to the Divisions and Committees with respect to publishing resumés of their activities in the JOURNAL, to stimulate interest.

The Vice-President inaugurated the first general meeting of Division and Committee chairmen at a stated luncheon at the time of the annual meeting at Troy. This is believed to be a very necessary medium of general communication between the Vice-President in charge and the several Division and Committee chairmen. All of the chairman present expressed great interest in such meetings. Vice-President Robertson who will succeed me will undoubtedly implement many of the suggestions which were made.

The Vice-President in charge of Divisions and Committees attended all meetings of the Executive Board and Council during the year. He also participated as a member of the Society's Committees on Manpower, Salary, Constitution, and Military Affairs.

Respectfully submitted,

THORNDIKE SAVILLE, *Vice President in charge of Instructional Division Activities and Dean of Engineering, New York University*

July 2, 1949

Report of the Engineering College Administrative Council

The Engineering College Administrative Council of the American Society for Engineering Education has been most active and is making many contributions in the field of engineering administration. An excellent program was held in Washington, D. C., November 8, 1948. One of the highlights of the program was President Freund's address on the theme "Partnership with Industry." President Freund's paper, along with other papers presented at the meeting, has already been published in the JOURNAL.

The Executive Committee of the Engineering College Administrative Council held a meeting in Austin, Texas, June 17, 1948, and another meeting in Washington on November 8, 1948. At these Executive Committee meetings programs for the general meetings and conferences were organized and, in addition, committees were activated to carry out regular and special assignments for the year.

In addition to appointments of committees, new By-Laws were enacted under date of August 1, 1948, and approved by the Society effective July 1, 1949.

Special Report

Building Study Survey, Dean J. H. Lampe, University of North Carolina, Chairman.

At the November 8, 1948, meeting of the Executive Committee of the Engineering College Administrative Council, Dean Lampe submitted a report of the Building Study Survey. After discussion he was authorized to issue a final report restricting information to include only building facilities for instruction and research work in engineering completed or authorized since January 1, 1945. This final report was issued to the membership as of March 7, 1949. (A copy is attached as Appendix II.)

Committee Reports

Salary Study Committee, Dean W. C. White, Northeastern University, Chairman.

Real progress has been made by the Salary Study Committee in its work of comparing teaching salaries in engineering institutions with teaching salaries in other professional schools and with engineering salaries in industry.

The problem of comparing teaching salaries with engineering salaries received in industry is a very difficult one. However, at its meeting in Detroit on October 30, the Committee decided to use as an industrial salary basis the data contained in the report of the Engineers' Joint Council entitled "The Engineering Profession in Transition."

A full report was presented by Dean White, chairman, at the annual meeting on Thursday, June 23, 1949, at Troy, New York. Bound volumes of this report were distributed. A final report is to be made to the Carnegie Corporation in the near future, after which the Committee will have completed its work.

The membership of the Salary Study Committee is: Dean W. C. White, Northeastern University, *chairman;* Dean C. L. Eckel, University of California; President T. K. Glennan, Case Institute of Technology; Dean Thorndike Saville, New York University; Mr. Malcolm Kispert, Massachusetts Institute of Technology, secretary; Dean S. S. Steinberg, University of Maryland, member ex-officio.

Committee on Military Affairs, D. B. Prentice, Scientific Research Society of America, Chairman.

Dr. Prentice has given much personal thought and consideration to the current situation of Selective Service and R.O.T.C. problems as they relate to engineering colleges. Present plans call for selection of individuals by the local boards with full discretion rather than on the basis of directives from national headquarters. Any memoranda from General Hershey's office will be advisory, not mandatory.

While no specific changes in the administration of the R.O.T.C. have been ordered for the current academic year, plans are being considered, apparently, which would introduce many serious difficulties for the engineering colleges during the year 1949–50. It has been indicated that specialization of course material might be included in the freshman and sophomore years for R.O.T.C. students. A freshman engineering student might elect signal corps, engineer corps, artillery or any other branch offered and the hour plan would have to provide for this freedom of choice. Such a development would introduce serious scheduling difficulties and requires added time for the R.O.T.C. program.

On Wednesday, June 22, at 2:00 P.M., the Committee on Military Affairs held a meeting in the Troy Building, Dr. D. B. Prentice, chairman, presiding. The theme of this meeting was the consideration of Selective Service, R.O.T.C. and N.R.O.T.C. matters. The program was as follows:

1. Selective Service and the Engineering Colleges. Major General L. B. Hershey, Director of Selective Service.
2. Discussion opened by Dr. M. W. Trytten, National Research Council.
3. Plans of the Reserve Officers Training Corp. Brig. General W. Westover, R.O.T.C., Lt. Colonel G. M. Bacharach, R.O.T.C.
4. Discussion opened by T. Saville, Vice-president A.S.E.E., New York University.

The membership of the Committee on Military Affairs is: D. B. Prentice, *Chairman;* Dean N. S. Hibsham, Pratt Institute; Dean Thorndike Saville, New York University; Dr. M. H. Trytten, National Research Council; President M. D. Whitaker, Lehigh University.

Manpower Committee, Dean L. M. K. Boelter, University of California, Chairman.

Reports of the Manpower Committee show that the committee has had one meeting and very effective activities through correspondence and keeping abreast of the manpower problem.

Dean Boelter, chairman of the committee, started this year's activities through a joint understanding with Mr. M. M. Boring of the Engineering Joint Council's General Survey Committee. The Engineering Joint Council is accumulating information concerning starting rates currently offered engineering seniors and graduate students, and also information concerning the demand for engineering graduates this year as compared with last year.

The Manpower Committee plans to use the information obtained by the General Survey Committee of the Engineering Joint Council as basic data for the report. Further, the committee will work closely with the Bureau of Labor Statistics on the problems of manpower requirements for professional engineers. The committee is also conducting this study to determine the rate of utilization of United States engineering college graduates.

At the June meeting of A.S.E.E. the Manpower Committee had a most effective program. A sub-committee consisting of Messrs. Armsby, *Chairman,* F. M. Dawson, Thorndike Saville, and S. C. Hollister prepared a summarization report on the manpower situation. This report was presented at the general session of E.C.A.C. by H. H. Armsby.

The Manpower Committee held a special conference at 2:00 P.M. on Thursday, June 23, Dean Boelter, *Chairman,* presiding. The program was as follows:

1. 1949 Demand for Engineering Graduates.
   a. M. M. Boring, General Electric Company.
   b. D. S. Bridgman, American Tel. & Tel. Company.
2. Employment Outlook for Engineers, H. Goldstein, Bureau of Labor Statistics.
3. Report of Subcommittee, H. H. Armsby, *Chairman,* U. S. Office of Education.

The membership of the Manpower Committee is as follows: Dean L. M. K. Boelter, University of California, *Chairman;* H. H. Armsby, U. S. Office of Education; M. M. Boring, General Electric Company; M. T. Carpenter, Research Dept., Standard Oil Co.; F. M. Dawson, University of Iowa; O. W. Eshbach, Northwestern Technical Institute; E. P. Hamilton, John Wiley & Sons; E. V. Hollis, U. S. Office of Education; S. C. Hollister, Cornell University; R. M. Kimball, Massachusetts Institute of Technology; C. T. Reid, California Aero. Technical Institute; Thorndike Saville, New York University; W. W. Squier, Sun Electric Corporation; M. H. Trytten, National Research Council.

Committee on Secondary Schools, Dean Everett D. Howe of the University of California, Chairman.

Dean Everett D. Howe most graciously accepted the work of directing this committee late in November, 1948, to succeed Dean Boelter who was relieved of the chairmanship in order to direct the work of the Manpower Committee.

The Committee on Secondary Schools held a special conference at the Troy meeting at 2:00 P.M., Wednesday, June 22, Dean Everett D. Howe, *Chairman,* presiding. The meeting was a panel discussion based on brief preliminary talks by panel members on the following topics:

1. Secondary Schools No. 1—"Secondary School Curriculum Problems as Related to Preparation for the Study of Engineering," Mr. Hamilton Acheson, Cobleskill Central School, Cobleskill, N. Y.
2. Secondary Schools No. 2—"Aims and Objectives of High School Mathematics and Science Courses," Mr. James T. Hepinstall, Philip Schuyler High School, Albany, N. Y.
3. Secondary Schools No. 3—"The Guidance Program in the High School," Dr. Carleton A. Moose, New York State College for Teachers, Albany.
4. Technical Institutes—"Skills and Knowledge Prerequisite to Technical Institute Curricula," Mr. Walter L. Hughes, Franklin Technical Institute, Boston, Mass.
5. College No. 1—"Selection of Students for the Study of Engineering," Professor Harry W. Case, University of California, Los Angeles.
6. College No. 2—"Socio-humanistic Studies in College, as Related to High School Preparation," Professor Jesse E. Thornton, University of Michigan.

In addition to the panel discussion there was a report on the National Council of Teachers of Mathematics by Dr. H. H. Armsby.

The membership of the Committee on Secondary Schools is as follows: Dean Everett Howe, University of California, *Chairman;* H. H. Armsby, U. S. Office of Education; W. S. Evans, University of Maine; M. P. Gaffney, New Trier High School, Monetka, Illinois; Professor A. B. Garrett, Ohio State University; W. L. Hughes, Franklin Technical Institute; P. G. Johnson, U. S. Office of Education; F. H. Miller, Cooper Union; J. G. Potter, A. & M. College of Texas; J. E. Thornton, University of Michigan.

The Executive Committee of the Engineering College Administrative Council consisting of the former and new members held a luncheon meeting, Thursday, June 23, 1949, at 1:00 P.M., during the meeting at Troy, New York. General business of the Council was conducted and arrangements looking forward to our fall meeting at Kansas City on October 28, 1949, were expedited.

The new officers and Executive Committee members who were elected at the Troy meeting are as follows: Dean F. E. Terman, Stanford University, *Chairman;* Dean J. H. Lampe, N. C. State College, *Secretary;* President A. S. Adams, University of New Hampshire; Dean O. V. Adams, Texas Technological College; Dean Kenneth A. Condit, Princeton University; Dean R. E. Vivian, University of Southern California; President F. L. Wilkinson, Jr., Rose Polytechnic Institute.

Respectfully submitted,

S. S. STEINBERG, *Vice President of the Society and Dean of Engineering, University of Maryland*

J. H. LAMPE, *Secretary of the E.C.A.C. and Dean of Engineering, University of North Carolina*

June 29, 1949

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	Spring, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 13, 1950	D. S. Clark, Purdue University
Middle Atlantic	Columbia University	Dec. 3, 1949	R. T. Weil, Jr., Manhattan College
National Capital Area	Washington, D. C.	Oct. 4, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Rochester	Oct. or Nov., 1949	H. W. Bibber, Union College

Report of the Engineering College Research Council 1948-49

As 1948–49 comes to a close, the Engineering College Research Council finds itself better than usually equipped to survey the area of its assignment.

Engineering research in all colleges and universities has grown at an exceedingly rapid rate in the years during and following World War II. This year the Research Council has a quantitative report on the size of this great collective enterprise.

Printing has just been completed on pre-publication copies of the 1949 *Review of Current Research and Directory of Member Institutions.* In this book is listed the title of each research project in engineering at each one of the Research Council's 81 member institutions. This 1949 edition is almost one-third again as large as its counterpart published in 1947. There are more than 4000 research project titles in it, representing over $35,000,000 in research expenditures.

The growth in engineering research activity is not confined to a few institutions or even to a section of the country. Fundamental research in engineering is underway in important proportions in every state of the Union. The Research Council's membership reflects this fact. To qualify for active membership in the Engineering College Research Council, a school must spend upwards of $10,000 over a three-year period on fundamental engineering research. In the past six months eight additional schools have met these qualifications and have become members of the Engineering College Research Council. They are:

University of Arkansas (College of Engineering)
Catholic University of America (School of Engineering and Architecture)
University of Denver (Industrial Research Institute)
Montana School of Mines (State Bureau of Mines and Geology)
Northeastern University (College of Engineering)
University of Notre Dame (College of Engineering)
Tufts College (School of Engineering)
Wayne University (Wayne Engineering Research Institute)

Earlier, in the fall of 1948, the University of California (Los Angeles) Department of Engineering was accepted for Active Membership.

The Administration of Research

As a great enterprise, engineering research in colleges and universities presents difficult and unconventional managerial problems. Last fall, because more information was needed about dealing with these unconventional problems, the Research Council sent a special questionnaire on sponsored research to all its members; more than 60 replied.

Nearly half of the 60 schools reported *no men* employed *full time* exclusively on sponsored research. Such research is being done by men who spend part of their time in the classroom, either teaching or studying, and part of their time in the laboratory. More than 800 engineering faculty members alone in these 60 institutions are engaged part-time in sponsored research activities, and their work represents about 8 per cent of the total faculty time. With very few exceptions, their participation does *not* re-

sult in any personal monetary gain. These facts would seem to indicate nearly perfect integration of research into educational activities.

Sponsored research in our engineering colleges is not a commercial money-making venture. It is a sound correlation of education and research serving industry as well as our educational programs, a vital part of our national life and welfare.

Because the problems of research administration are so complex and at the same time so important, the members of the Engineering College Research Council have been well represented at the Conferences on the Administration of Research at the Pennsylvania State College, beginning three years ago. At the invitation of the group, the Research Council is now preparing to assume a more active role in this activity, as one of several cooperating organizations.

Education in Research

The E.C.R.C.'s new *Review of Current Research,* which covers both sponsored and unsponsored activities, reports that 10,000 men and women are now taking active part in engineering research at educational institutions. Nearly half of these people are graduate students and more than another quarter are members of the teaching staffs. Of the 4000 research project titles reported, about one-quarter are sponsored by industries and industrial associations and one-quarter by military and civilian agencies of the government.

These figures all lead to one inevitable conclusion: the colleges and universities which are members of the Engineering College Research Council have, by a variety of administrative methods, achieved universally a remarkable coordination of effort between research and education. It is widely recognized that fundamental research is a necessary part of advanced education in engineering and a necessary background in schools where effective undergraduate instruction is to take place. Here is evidence that such basic research, some of it for outside sponsors whose interests are not fundamentally in education, can indeed become part and parcel of the educational process and a part of the very academic life at each institution involved. In the *Review of Current Research* there is the best possible evidence in support of the conviction that educational institutions can (and must) maintain their activities in fundamental research—integrated with education and free from those routine projects which commercial research organizations are formed to study.

Research Council Publications

This story of educational institutions' fundamental research is one worth telling, and it is to this purpose that the Research Council's publications activities are directed.

In order to help its members tell the story of their activities, the Research Council met in Washington, D. C., in November, 1948, to hear seven editors and writers describe how to help professional writers deal with engineering subjects. The seven speakers and their papers were:

Herbert B. Nichols, Science Editor of the *Christian Science Monitor:* "Applied Science in the Daily Press."

John M. McCullough, Editorial Staff of the *Philadelphia Inquirer:* "The 'Working Press.'"

Ron Ross, News Editor of *Science Service:* "Science Service."

Irving J. Gitlin, Science Director of the Columbia Broadcasting System: "Science on the Radio."

Edward D. Fales, Associate Editor of *Science Illustrated:* "Photographs and Diagrams: How the Magazines Can Help."

Paul Wooton, President of the National Conference of Business Paper Editors: "The Business Press."

Philip W. Swain, Editor of *Power:* "Research in the Engineering Press."

One permanent result of this meeting is a little booklet of Proceedings containing the seven papers, entitled "Telling the

Story of Engineering Research." It is full of wise words and good advice for all engineers (and scientists) who would like to help newspapermen and editors and writers describe what has been accomplished, what is underway, why, and how. This booklet has already achieved a warm reception in both engineering and journalism circles; its publication may eventually be a financially self-supporting project.

In addition to the *Review of Current Research* and the booklet on "Telling the Story of Engineering Research," the Research Council published the Proceedings of its 1948 Annual Meeting during the past few months. This volume contains those papers given at Austin, Texas, which were deemed of special interest to research directors and administrators. Like other publications of the Research Council, copies of the Proceedings are sold at approximately the cost of printing. But the cash sales of most publications are small and complimentary distribution is relatively large; thus the dues received from Active Members in the Research Council actually make much of the publications program possible. The publications represent the Research Council's major expenditure, both of time and of money.

Research is Necessary to Progress

The Engineering College Research Council program for the 1949 Annual Meeting, as for last year's, carries as a slogan the truism that "Research is necessary for progress in engineering." It is in recognition of this fact that the Research Council has become an integral part of the American Society for Engineering Education. It is charged with assisting in the development of research facilities in engineering colleges. It is the hope of the Executive Committee of the Research Council that what has been accomplished this year may have helped to fulfill that charge. The Committee pledges its continued efforts toward a wider and better understanding of the role of fundamental research in educational institutions and in American life.

Respectfully submitted,

F. M. DAWSON, *Vice President of the Society and Dean of Engineering, State University of Iowa,*

J. I. MATTILL, *Secretary, Engineering College Research Council, and Assistant Director of News Service, Massachusetts Institute of Technology*

June 10, 1949

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of the

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Secretary's Report

The past year has witnessed a number of significant accomplishments contributing to the long-range objectives of the Society. The theme "Partnership with Industry," proposed by the President and endorsed by the Executive Board and the General Council, met with widespread approval among the Divisions and Sections of the Society, as evidenced by the many varied programs bearing upon this general theme. These meetings have served to establish a closer liaison between engineering colleges and industry, thereby providing a better understanding of the mutual problems and relationships of both.

Several new projects have been undertaken by Committees and Divisions of the Society, and considerable progress is being made on other studies now under way. When completed, these projects have promise of making significant contributions to the advancement of engineering education.

The Administrative Council and the Research Council have held highly successful meetings on subjects of widespread current interest. Separate reports on these activities are given by the Vice Presidents in charge of the Councils.

Ethics of Interviewing Procedures

During the past year, the Committee on Ethics of Interviewing Procedures completed its report "Recommended Procedures in Interviewing and Placement of College Seniors." The report was approved by the General Council of the Society in November, 1948, and was published in the March, 1949, issue of the JOURNAL. Approximately 1200 copies of the report were sent to presidents, deans, and personnel men in colleges, as well as to personnel men in industry. Numerous letters of commendation have been received, testifying both to the need for such a code and the excellence with which the Committee has discharged its responsibilities.

Visual Aids Projects

In order to facilitate the preparation of visual aids suitable for engineering instruction and to encourage their use, a Committee on Visual Aids has been formed under the Division of Educational Methods. This committee is formulating plans for industry-college cooperation in the construction of films, slides, working models, and other devices which would help to improve engineering instruction. As a means of providing a widespread exchange of ideas on visual aids, the Committee has arranged for a symposium on this subject at the annual meeting, as well as an exhibit of various audio-visual aids and models prepared by engineering faculty members.

Measurement and Guidance Project

A Measurement and Guidance Project has, for a number of years, been jointly sponsored by the A.S.E.E. and the Engineers' Council for Professional Development. The project, financed in part by the Carnegie Foundation, was responsible for constructing, administering and grading the Pre-engineering Inventory Tests and the Sophomore Achievement Tests. During the past year an organization known as the Educational Testing Service was founded for the purpose of consolidating the testing services in various educational fields, including the College Entrance Board Examination, the Graduate Record Examination and others. The new Educational Testing Service was financed by the Carnegie Foundation

which concurrently withdrew its support from the Measurement and Guidance Project as a separate testing project. In November, the General Council of the Society voted to approve a three-way agreement with the E.C.P.D. and the Educational Testing Service, whereby the Measurement and Guidance Project would be transferred to the Educational Testing Service. The agreement, which does not impose any financial obligation upon the Society, provides for an Advisory Council with representatives from the A.S.E.E. and E.C.P.D. to assist the Testing Service in the administration of the project.

Teaching Manual

A manual on effective teaching methods is being prepared by a committee of the Society. The Manual will be published by McGraw-Hill Book Company.

Enrollment Statistics

For a number of years the Society has collected and tabulated statistics on enrollment in engineering colleges. Various agencies of the U. S. Government have expressed considerable interest in these statistics and the U. S. Office of Education has offered to handle the work of tabulating the statistical data. An agreement has been prepared, whereby the U. S. Office of Education and the A.S.E.E. would cooperate in the preparation of the engineering enrollment statistics. This agreement was approved, with modifications, by the Executive Board and was approved by the General Council at its meeting on June 24, 1949.

Constitutional Amendments

The Committee on Constitution and By-Laws has prepared a number of constitutional amendments to correct certain provisions in the Constitution which have given operational difficulty. These amendments were approved by the three Councils of the Society at the Annual Meeting and will be submitted to the Society membership by letter ballot for ratification.

Participation in American Standards Association

The Society is taking an active part in the work of various standards committees of the American Standards Association. New representatives have recently been appointed to committees in the fields of civil engineering, physics and electrical engineering, and engineering drawing.

Summer School

A summer school, sponsored by the Mechanical Engineering Division was held at Rensselaer Polytechnic Institute following the Annual Meeting. The program included teaching methods, professional development of the instructor, subject material for general and specialized mechanical engineering courses, integration of the curriculum, professional development of the student, and preparation of the student for his first job.

Activities for Younger Members

A committee has been appointed to submit proposals for activities which would increase the participation of younger members in the affairs of the Society. It was the opinion of the Executive Board that the younger members, of instructor and assistant professor rank, should be given an opportunity to organize activities which would appeal particularly to their interests and make it possible for them to participate more actively to the affairs of the Society.

Journal of Engineering Education

The new cover design of the JOURNAL, with the rotating color sequence for consecutive months, has met with enthusiastic approval. The new type size and format effects an appreciable saving in printing costs, with very little impairment of readibility.

A complete listing of officers of the Society was included in the October issue and a page giving the dates of Section meetings was included in each issue. This practice will be continued in the future. It is planned to include a "Letters

to the Editor" page in future issues of the JOURNAL. A page will also be made available to Divisions and Committees of the Society in future issues of the JOURNAL.

Annual Meeting

The local committee at Rensselaer Polytechnic Institute is to be commended for the zeal and enthusiasm with which they handled the preparations for the Annual Meeting. Excellent cooperation has also been received from the Divisions and Committees in completing the program arrangements early in the year. A considerable amount of liaison work is necessary between the host institution and the Secretary's Office in assigning conference rooms, dining rooms, and in eliminating the many inevitable conflicts. It is therefore necessary to set an early deadline date for program information in order to assure mailing of the preliminary program before the first of May.

This year, an attempt has been made to get out advance publicity releases on the Annual Meeting. Summaries of talks were also mimeographed for distribution at each of the conferences.

Partnership with Industry

The Committee on Relations with Industry has taken an enviable lead in developing the theme for the year by arranging for an industry-college forum at the Annual Meeting on the subject "Development of the Young Engineer." Outstanding industrialists were invited to speak on: licensing of the engineer, the engineer and unionism, and professional development of the engineering graduate. Invitations to attend the meeting were sent to a select list of industrialists and college administrators throughout the country. The Committee on Relations with Industry also made arrangements for one of the general sessions on the subject "Industry-College Relations."

International Night

The Committee on International Relations extended invitations through the embassies in Washington to engineering educators throughout the world to attend the Annual Meeting of the Society and to participate in an International Night dinner and conference. This meeting was attended by approximately 45 engineering educators and administrators from foreign countries, in addition to officers and members of the Society. The international delegates spoke on the background and current problems associated with engineering education in their respective countries. Meetings of this character will inevitably extend the benefits of the Society activities into many lands. They will help to establish the bond of friendship among engineering educators throughout the world and impart a deeper understanding of each other's problems and goals. The Committee is to be highly commended for its pioneering work.

Section Meetings

Interest in Section activities has shown a marked increase, as evidenced by the fact that attendance at most Section Meetings exceeded all previous records. The Sections and Divisions are to be commended for the high quality of programs at their various meetings. It is heartening to note that, in Section and Division meetings, increased emphasis is being placed upon methods of improving engineering instruction. For many years, the primary emphasis has been upon "what should be taught," whereas during the past year considerable emphasis has shifted to "how can it best be taught."

A number of deans of engineering colleges are encouraging their younger faculty members to attend the Section meetings, since these meetings make it possible for them to get the benefits of society participation at considerably less expense than attendance at an annual meeting of the Society.

Membership

The Membership Committee nas consisted of a chairman for each state and committee members from each engineer-

ing college within the state. The energetic work of this committee has resulted in the addition of 1050 new members during the year, representing an 18 per cent increase in membership. Approximately 4500 letters of "invitation-to-join" were sent to prospective members whose names were supplied by the membership committee. An effort was also made to increase the membership of the Society from among the ranks of industrial executives who have shown an interest in engineering education. Recommendations of prospective industrial members were solicited from deans of engineering colleges and members of the Committee on Relations with Industry, and letters of "invitation-to-join," signed by the President, were sent to each prospective member. This has resulted in 122 new industrial members.

During this year, there have been 162 resignations, 29 deaths, and 53 members dropped for non-payment of dues.

Finances

The inescapable inflation in prices has been felt just as acutely among engineering societies as it has in other walks of life. A little over a year ago the Society was informed of a 20 per cent increase in the cost of printing the JOURNAL and in January of this year an additional 22 per cent increase was announced. Other items of Society expense have suffered similar increases.

Despite rapidly rising costs, the Society has successfully maintained a balanced budget and the Treasurer's report shows a profit of $3741.02 in the year's operations. This can be attributed largely to the success of a vigorous membership campaign and the solicitation of increased advertising in the JOURNAL during the past two years. Together, these two items have increased the annual revenue of the Society by $11,500.

There are, however, certain conspicuous omens which cannot safely be ignored. If prices should continue to rise in the future as they have in the past, it is questionable whether the Society can rely indefinitely upon increasing membership to relieve the financial stress. It seems logical that future membership campaigns might not yield as high returns as those during the past two years. Also, the rising cost of the JOURNAL is consuming an ever-increasing portion of the total dues receipts. Thus, in 1942, the cost of the JOURNAL per member was $2.12, as compared with $3.50 per member six years later in 1948. Furthermore, the routine task of servicing the enlarged membership—the dues notices, dues receipts, changes of address, preparation of the *Yearbook*, etc.—adds to the burden of an already overworked headquarters staff.

It has always been the policy of the Society to operate with a small headquarters staff on a "decentralized" plan, whereby the Divisions, Sections, and Committees handle much of their routine business. The headquarters then assumes responsibility for the national affairs of the Society, including the membership records, the editing of the JOURNAL, the arrangements for the Annual Meeting, and the maintaining of close liaison with the various Councils, Divisions, Sections, and Branches of the Society. The headquarters is also called upon to handle special projects which are frequently undertaken by the Society. Under this basic plan of operation, it has thus far been possible to handle the business of the Society with two office secretaries to assist the Secretary of the Society. This, in turn, has made it possible to operate successfully with a dues structure of from $5.50 to $7.00, which is approximately one-third that of other national engineering societies. However, under this plan of operation, the Society cannot hope to offer extensive collateral services comparable to those of other engineering societies. If the Society should attempt to duplicate these collateral services, it would inevitably require a considerable expansion of the headquarters staff, with a consequent increase in overhead and higher dues.

If the Society is to continue to operate with a small headquarters staff and still

accomplish its high objectives, it would seem necessary to concentrate the major attention upon those projects which contribute directly to the primary objectives of the Society—"the advancement of education in all of its functions which pertain to engineering and allied branches of science and technology" while at the same time subordinating the collateral benefits which burden the headquarters staff but contribute only marginally to the primary objectives of the Society.

The Secretary wishes to acknowledge the helpful assistance of the officers of the Society who have given generously of their time and effort in order to assure successful operation of the affairs of the Society. Your President and other officers were in frequent attendance at Section meetings throughout the country.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

June 24, 1949

Sections and Branches

The **Michigan Section** of the A.S.E.E. held its Annual Meeting on May 7, 1949 at Michigan State College. L. G. Miller welcomed the group.

At the General Session, C. L. Brattin, Chairman, appointed the following committees:

Nominating Committee: R. H. Schoonover, C. A. Brown, F. L. Schwartz, F. J. Budde and L. L. Henry.

Resolutions Committee: A. R. Carr, R. H. Spahr and H. E. Mayrose.

C. L. Allen gave a brief talk on eleven challenges which lie ahead in Engineering Education. This was followed by an address by J. W. Parker, of the Detroit Edison Company, entitled "Education for a Profession."

Officers nominated and unanimously elected for the coming year were: Chairman: H. M. Hess; Vice Chairman: H. M. Dent; Secretary-Treasurer: W. P. Godfrey.

The evening's speaker was C. J. Freund, President, A.S.E.E., who spoke on "Partnership With Industry."

The Meeting was adjourned with the reminder that the 1950 Meeting would be held at Wayne University.

The Annual Meeting of the **Pacific Northwest Section** of the A.S.E.E. was held June 16 and 17 on the campus of Montana State College at Bozeman, Montana. F. A. Thomsom presided over the First Session which included a number of institutional reports. C. A. Mockmore spoke on "A Decade of Experience with E.C.P.D." and A. E. Adami presented a paper on "A Field Course in Plance Surveying." H. E. Wessman presided over the Second Session and A. S. Janssen over the Third, which included the two papers, "Departmental Organization" by S. H. Graf and "A Coordinated Program for Engineering Graduate Research in the Northwest" by F. D. Farquharson. In the Fourth Session, K. Doane, P. Mann, R. B. VanHorn and B. T. McMinn participated in a "Symposium on Work Load Evaluation of Engineering Faculty." G. W. Gleeson presided. The Fifth Session contained a series of Departmental Group Meetings, and was followed by a dinner presided over by E. W. Schilling. R. R. Renne gave an address of welcome.

Officers were elected as follows: Chairman—A. S. Janssen; Vice Chairman—C. L. Reiser; Secretary—P. Mann.

Since the National Meeting will be held in Seattle next year, no Section Meeting is planned. The 1951 Meeting will be held at the University of Idaho.

Report of the Treasurer, 1948-49

Evanston, Illinois
July 15, 1949

Mr. James S. Thompson, Treasurer
American Society for Engineering Education
White Plains, N. Y.

Dear Mr. Thompson:

In accordance with your instructions, we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1949, and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Changes in Funds
Exhibit III—Comparative Statements of Income and Expense
Exhibit IV—Comparative Statements of Receipts and Disbursements

In connection with the statements as of June 30, 1949, we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

As was noted in our report last year, placing the records of the Society on the basis of a fiscal year ending June 30 resulted in the 1948 statements being prepared for a 12½ month period. This also resulted in the inclusion in the 1948 statements of the expenses of two annual meetings, as the 1947 statements were prepared prior to the annual meeting and the 1948 statements after the annual meeting.

In our opinion these statements fairly present the position of the Society at June 30, 1949, and the results of its operations for the period then ended.

Yours truly,

(Signed) Ernest C. Davies
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMPARATIVE BALANCE SHEETS

Assets	June 30, 1948	June 30, 1949
Current Fund:		
Cash in State Bank & Trust Co.	$37,175.25	$38,512.44
Cash in Mellon National Bank	—	689.42
Petty Cash Fund	300.00	300.00
U. S. Government Bonds Series G	20,700.00	20,700.00
	$58,175.25	$60,201.86

	June 30, 1948	June 30, 1949
Life Membership Fund:		
Cash—Checking	$ 104.18	$ 129.70
U. S. Government Bonds Series G	1,000.00	1,000.00
	$ 1,104.18	$ 1,129.70
B. J. Lamme Fund:		
Cash—Checking	$ 335.89	$ 335.89
Principal Cash in Hands of Trustee	847.67	9.00
Securities and Mortgages	4,296.58	5,132.73
	$ 5,480.14	$ 5,477.62
Accounts Receivable:		
Advertising	$ 1,976.97	$ 1,855.00
Less: Reserve for Bad Debts	———	315.00
	$ 1,976.97	$ 1,540.00
Dues	1,800.00	1,200.00
Westinghouse Educational Foundation	159.58	109.58
Income Cash in Hands of B. J. Lamme Fund Trustee	116.11	110.71
	$ 4,052.66	$ 2,960.29
Inventory (Nominal)	$ 1.00	$ 1.00
Furniture and Fixtures (Nominal)	$ 748.78	$ 748.78
Total Assets	$69,562.01	$70,519.25
Liabilities		
Current Liabilities		
Accounts Payable—Publications	$ 1,368.27	$ 1,600.00
Other Accruals	———	105.86
	$ 1,368.27	$ 1,705.86
Prepaid Membership Dues	$ 1,178.75	$ 1,099.75
Funds:		
Life Membership Fund	$ 1,104.18	$ 1,129.70
B. J. Lamme Fund	5,596.25	5,477.62
General Education Board Southeast Section	17,450.00	14,950.00
Carnegie Corporation—Eng. Salary Survey	5,730.72	4,745.21
	$29,881.15	$26,302.53
Surplus—General Fund	$37,133.84	$41,411.11
Total Liabilities and Surplus	$69,562.01	$70,519.25

COMPARATIVE STATEMENT OF CHANGES IN FUNDS

	12½ Months Ended June 30, 1948	12 Months Ended June 30, 1949
GENERAL EDUCATION BOARD, S.E. SECTION		
Balance at Beginning of Period	$10,000.00	$17,450.00
Add: Contribution during the Period	10,350.00	———
	$20,350.00	$17,450.00
Less: Charges during the Period	2,900.00	2,500.00
Balance at End of Period	$17,450.00	$14,950.00
CARNEGIE CORPORATION, ENGINEERING SALARY SURVEY		
Balance at Beginning of Period	$ 6,000.00	$ 5,730.72
Add: Transfer to General Fund	———	269.28
	$ 6,000.00	$ 6,000.00
Less: Charges during the Period	269.28	1,254.79
Balance at End of Period	$ 5,730.72	$ 4,745.21
SURPLUS, GENERAL FUND		
Balance at Beginning of Period	$32,798.53	$37,133.84
Add: Income credited to Lamme Fund in 1948 instead of General Fund	———	116.11
Summer School Fund previously independent of General Fund	———	689.42
Excess of Income over Expense for the Period	$ 4,335.31	$ 3,741.02
	$37,133.84	$41,680.39
Less: Transfer Charge from Carnegie Corporation Salary Survey	———	269.28
Balance at End of Period	$37,133.84	$41,411.11

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	12½ Months Ended June 30, 1948	12 Months Ended June 30 1949	1949–50 Budget
Income:			
Current Dues—Individual	$30,825.44	$33,145.83	$34,600.00
Institutional	6,500.00	6,862.50	6,900.00
Back Dues	586.50	———	———
Sale of Publications	1,760.12	1,793.78	1,800.00
Advertising	6,870.70	8,354.68	8,700.00
Refunds	319.64	74.89	———
Interest on Government Bonds	417.50	542.50	530.00
Miscellaneous	.77	———	———
E.C.R.C. (Sale of E.C.R.C. Publications)	2,333.38	2,053.94	———
Income—B. J. Lamme Fund	———	110.71	———
Total Income	$49,614.05	$52,938.83	$52,530.00

	12½ Months Ended June 30, 1948	12 Months Ended June 30 1949	1949–50 Budget
Expense:			
Cost of Publications	$18,024.87	$20,542.29	$23,000.00
Administrative Salaries	9,302.61	9,545.40	10,600.00
Retiring Emeritus	653.33	1,360.00	1,360.00
Officers' Traveling Expense	639.90	825.85	1,200.00
Travel, Secretary's Office	640.70	788.47	900.00
Postage, Telephone, and Telegraph	1,794.29	1,816.19	1,800.00
Supplies and Sundry Printing	1,537.32	2,177.45	2,200.00
Cost of Moving Secretariat	3,138.99	———	———
Dues—American Council on Education	100.00	100.00	100.00
Contribution to E.C.P.D.	500.00	500.00	500.00
Provision for Bad Debts	———	315.00	———
Expense 1947 Meeting	1,535.41	———	———
Expense 1948 Meeting	1,317.02	———	———
Expense 1949 Meeting	———	2,040.78	———
Expense 1950 Meeting	———	———	2,000.00
Expense E.C.A.C.	1,119.14	398.77	2,200.00
Expense E.C.R.C.	3,018.78	7,051.08	3,350.00
Committees and Conferences	590.81	487.06	1,000.00
Expense—Lamme Trust Fund	566.33	239.03	———
Contingencies and Special Projects	799.24	1,010.44	1,200.00
Total Expense	$45,278.74	$49,197.81	$51,410.00
Excess of Income over Expense	$ 4,335.31	$ 3,741.02	$ 1,120.00

COMPARATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS

	12½ Months Ended June 30, 1948	12 Months Ended June 30, 1949
Balance on Hand at Beginning of Period	$31,582.28	$37,175.25
Receipts:		
Current Dues—Individual	$28,474.94	$31,666.58
Institutional	6,375.00	6,662.50
Back Dues	1,586.50	1,100.50
Dues in Advance	1,178.75	1,099.75
Sale of Publications	1,760.12	1,915.75
Advertising	6,393.73	8,354.68
Interest on Bonds	417.50	542.50
Income—B. J. Lamme Fund	———	113.87
Refunds	319.64	74.89
Miscellaneous	.77	———
Westinghouse Educational Foundation	250.00	250.00
General Education Board, SE Section	10,350.00	———
Funds transferred from E.C.R.C.	2,333.38	2,053.94
Summer School transferred to General Fund	———	689.42
Total Receipts	$59,440.33	$54,524.38

	12½ Months Ended June 30, 1948	12 Months Ended June 30, 1949
Disbursements:		
Cost of Publications	$19,287.98	$20,310.56
Administrative Salaries	9,302.61	9,545.40
Retirement Emeritus	653.33	1,360.00
Travel, Secretary's Office	640.70	788.47
Officers' Traveling Expense	639.90	825.85
Postage, Telephone, and Telegraph	1,794.29	1,776.72
Supplies and Sundry Printing	1,537.32	2,177.45
Cost of Moving Secretariat	3,138.99	———
Dues—American Council on Education	100.00	100.00
Contribution E.C.P.D.	500.00	500.00
Expenses 1947 Meeting	369.16	———
Expenses 1948 Meeting	1,317.02	———
Expenses 1949 Meeting	———	1,989.39
Expenses E.C.A.C.	1,119.14	398.77
Expenses E.C.R.C.	3,018.78	7,051.08
Committees and Conferences	590.81	472.06
Westinghouse Award	302.48	200.00
Expense—B. J. Lamme Fund	566.33	236.79
Contingencies Expense	799.24	575.42
Expense—Carnegie Survey	269.28	1,254.79
Award General Education Board	2,900.00	2,500.00
Purchase of Government Bonds	5,000.00	———
Special Project Expense	———	435.02
Total Disbursements	$53,847.36	$52,497.77
Balance on Hand at End of Period:		
State Bank and Trust Company—Checking	$37,175.25	$38,512.44
Mellon National Bank—Savings	———	689.42
Total Balance on Hand	$37,175.25	$39,201.86

Respectfully submitted,

JAMES S. THOMPSON,
Treasurer

Deaths During 1948-49

Adams, O. L.	Focke, T. M.	Houser, Shaler C.	Seamon, W. F.
Berry, G. M.	Forman, A. H.	Hutchinson, R. C.	Seegrist, W. H.
Boase, A. J.	Gately, E. R.	Lear, John E.	Simon, Arthur
Bodman, E. P.	Gould, Archie B.	Lilly, Scott B.	Wilson, William
Brule, C. G.	Greene, John W.	Locke, Chas. E.	Woodbury, C. V.
Campbell, W. B.	Hall, Philip R.	Lynn, A. J.	Work, W. R.
Eames, Jesse J.	Hook, Warren H.	Roehrig, G. F.	Wright, R. V.
Ebaugh, W. C.			

There were 162 resignations during the 1948-49 fiscal year.

Annual Report of Manpower Committee

This report was prepared by a subcommittee composed of Messrs. Armsby, *Chairman,* Dawson, Hollister, and Saville. The subcommittee assumed full responsibility for the report, which has not been submitted to the full committee.

The Manpower Committee of ASEE, originally appointed by the President, whose previous reports have been published in the issues of the JOURNAL OF ENGINEERING EDUCATION dated October 1947 and September 1948, was reappointed in the fall of 1948 by the President of the Engineering College Administrative Council. Close contact has been maintained during the year with the General Survey Committee of the Engineers' Joint Council, and with the Bureau of Labor Statistics of the U. S. Department of Labor.

A subcommittee (composed of Messrs. Trytten, Chairman, Armsby, and Goldstein) has conferred with officials of the Census Bureau, with the Bureau's Interdepartmental Advisory Committee, and with the National Resources Planning Board, and has made recommendations to these groups that several new categories be added to those formerly employed in the National Census for designating people working in the fields of the sciences and of engineering, and that college teachers be subdivided according to their specialty rather than all being counted simply as teachers. It is the hope of the subcommittee that these changes will be incorporated into the 1950 census. If so, they should help to obtain a better base for future studies.

Future Supply of Engineering Graduates

The Compton and Armsby reports in 1946, and previous reports of this Committee, based predictions of numbers of graduates on pre-war mortality rates. There is evidence indicating that current mortality rates are higher than those prevailing in pre-war years. The Armsby report in 1946 predicted 38,000 graduates for the school year 1947–48. An estimate by the Committee in the fall of 1947 reduced this to 31,000. The February issue of the *ASEE Journal* reported 27,000 graduates, a decrease of nearly 25 per cent from the estimate made in the fall of 1946. This increased mortality is probably due to increased economic pressure on veterans, coupled with the fact that many veterans have learned that they are not adapted to the engineering curriculum to which they were attracted by war experiences. Presumably attrition rates will return to normal in the near future.

It should be pointed out that the ASEE reports on enrollments and degrees do not include all college students who are pursuing engineering curricula. The latest ASEE enrollment report lists 147 colleges, and reports enrollments and degrees granted in 144 of them. Included in the list are ten colleges which have not been accredited in any curriculum by ECPD. The U. S. Office of Education study of degrees granted in American colleges last year lists engineering degrees conferred by 39 additional colleges. It is likely that to the general public and to many employers of engineers the recipients of these degrees are in direct competition with those graduating from the colleges listed in the ASEE report. The number of graduates from these 39 colleges is about 3000, which probably must be considered as an addition to the supply of engineering graduates previously considered by this Committee.

THE JOURNAL OF ENGINEERING EDUCATION for March 1949 contains an article by Dean S. C. Hollister of Cornell Uni-

versity entitled "Post-War Engineering Enrollment Rapidly Adjusting to Near Pre-War Level." Dean Hollister calls attention to the rapidly declining freshman classes in engineering, and indicates by careful analysis that both the freshmen entrants and the prospective degrees issued are rapidly returning to the pre-war gradient, in other words, to what we might expect they would be had there been no World War. His study confirms the opinion expressed by the ASEE Manpower Committee's 1948 report to the effect that supply and demand of engineering graduates might be expected to be in balance by 1951.

Dean Hollister's predicted graduation figures (40 thousand in 1949, 40 thousand in 1950, and 31 thousand in 1951) are slightly less than would be obtained by applying pre-war mortality rates to last fall's enrollment figures as reported in the *ASEE Journal,* and do not include graduates of the unaccredited colleges just mentioned, which might increase the number of graduates by 10 per cent.

Certain factors might be mentioned which may be expected to operate in the direction of increasing engineering enrollments still further. Among these factors are (a) the rapid and continuing increase in the percentage of college-age youth who attend college; (b) the effects of the G. I. Bill, not merely on the veterans themselves, but on their friends and relatives; (c) the report of the President's Commission on Higher Education; (d) new scholarship programs, such as the N.R.O.T.C. and the proposed programs of the Army and the Air Forces, the proposed establishment of a National Science Foundation, and the possible establishment of a general program of Federal Scholarships; and (e) the possible establishment of engineering curricula in additional colleges. However, it is the feeling of the subcommittee that in spite of these factors tending to increase engineering enrollment, the number of engineering graduates in the next two years can be expected to be appreciably smaller than previously estimated by the Committee, but much larger than the pre-war gradient figures.

Demand for Engineering Graduates

The Bureau of Labor Statistics estimates an *average* annual need for engineering graduates of between 17 and 18 thousand during the early part of the next decade, increasing to an annual demand of about 21 or 22 thousand by 1960. This estimate is based on actual numbers of engineers needed for engineering jobs, including anticipated expansions and the three kinds of attrition caused by death, retirement, and leaving the profession, but making no allowance for the fourth kind of attrition which affects an individual company without entering into the national picture—namely, that due to men transferring from one company to another.

The E.J.C. survey shows that 162 industrial firms and 31 State and governmental agencies which now employ 89 thousand engineers (out of a total of 4 million employees) hired some 10 thousand inexperienced graduate engineers in 1948, and that they expect to hire 8 thousand in 1949, a decrease of 21 per cent. The engineers now employed in these companies and agencies are estimated to constitute approximately one-third of all employed engineers in the country. If the same ratio of new engineers to engineers now employed prevails in the remaining industries and agencies of the country, this would indicate that some 31 thousand engineers were hired in 1948, which number would be reduced to 24 thousand in 1949. The Bureau of Labor Statistics has attempted to make a more accurate extrapolation of the E.J.C. figures, industry by industry, and has arrived at an estimate of 27 thousand for 1948 and 21 thousand in 1949, excluding government agencies and the construction industry, in which they felt the E.J.C. samples were not representative. In other words, there is no significant difference between the results of the two methods of extrapolation of the E.J.C. sample.

It should be noted however, that these

estimates, based on judgments of industrial and governmental employment officials, of necessity include allowances for the fourth kind of attrition, the kind caused by men transferring from one company to another. Just how much duplication this introduces into an estimate of national need is not known, but certainly it is an important factor. The subcommittee hopes that future studies can be formulated in such a way as to secure some valid information on this important aspect of the manpower situation.

On the other hand, all of these estimates are concerned with actual present or definitely foreseen short term needs for engineering graduates to fill engineering jobs, and do not sufficiently reflect the well-known fact that many engineering graduates find employment in non-engineering work, especially in administrative or technical sales positions. Nor do they, in the opinion of the subcommittee, make sufficient allowance for the fact that engineering is still a growing and expanding profession.

Previous reports of this Committee have pointed out that not only the total number of engineers but also the ratio of engineers to total employment has been steadily rising ever since employment statistics have been assembled. Many factors operate toward a continuation of this increase in the ratio of engineers to total employment. Among these are: (a) the great increase in the use of engineers by government agencies, particularly the Armed Forces; (b) the continually increasing complexity of technology; (c) the effect of war-time experiences which demonstrated the value, and in many cases the absolute necessity, of engineering services; (d) the continually increasing intensity of competition in business, which creates a need for continually increasing efficiency in the use of manpower, materials, power, and equipment; (e) the continually increasing need for and use of research by industry and government; and (f) the "yeastiness" of the profession —the tendency for engineers to develop new processes and services which create needs for new kinds of engineers and technicians, such as the recent developments in radio and electronics applications, plastics and other chemical products, and the rapidly unfolding field of utilization of atomic energy.

All these factors and others result in what might be called the "horizontal spread" of the use of engineers into additional industries, particularly small industries, as well as the "vertical spread" within industries previously using engineers, and combine to greatly increase the demand for engineers.

Thirty-one thousand, the estimated hirings for 1948, is just the number of engineering graduates reported in the U. S. Office of Education study of degrees. Twenty-four thousand, the number of hirings indicated for 1949, is considerably less than the probable number of engineers who will be graduated in 1949. These figures, based on estimates of industrial and governmental employment officials, would seem to indicate a surplus of some 16 thousand engineers this year, but it is the firm conviction of the subcommittee, based on opinions of college officials, that no such surplus exists. No actual statistics are at hand, but consultations with deans of engineering in many parts of the country indicate that by and large the graduates of this year will be placed at the time of graduation or soon thereafter. No information is at hand as to the number who will be placed in non-engineering positions. The general picture seems to be that placement of graduates is slower than it has been for the past few years, and that the boys are not getting as many offers among which they may choose, but very few engineering deans expect any real difficulty in placing their graduates this year. It seems therefore that all of our estimates of demand must be increased over previous estimates made by this Committee.

General Conclusions

It seems probable, in view of the present large junior and sophomore classes, that students graduating from engineer-

ing colleges during the next two years may not all be immediately absorbed in engineering positions, that during the two years there may be a temporary excess of graduates over immediately available engineering positions of perhaps two-thirds of a year's normal supply. However, the subcommittee submits that there is a possibility that some of the factors which have been mentioned may operate to increase the demand to the point where there will be little or no excess.

Even if a temporary excess does develop, the subcommittee feels that there is no cause for great alarm in the situation. Engineering education has long been recognized as having great value as general education and as a good foundation for work in many professions other than engineering. The engineer's training in careful, thorough, accurate work, and in the scientific method of thought has been found useful in dealing with problems of human relations as well as with problems of utilizing the materials and forces of nature, and it is our belief that boys graduating in engineering during the next few years can expect to find employment, if not in strictly engineering work, at least in some activity in which their scientific training will not be wasted.

The question has been raised in many quarters as to whether or not we are educating in America too many engineers, too many lawyers, too many business men, and if the current and proposed increase in the number and proportion of college graduates will create a social unrest and widespread personal disappointment and sense of frustration. The committee feels that the answer to this problem has been well stated in the report of the President's Commission on Higher Education. In a recent address before the faculty of the State Teachers College at Indiana, Pennsylvania, Dr. John Dale Russell, Director of the Division of Higher Education of the U. S. Office of Education, said "The discussion in that report should allay the fears that anyone may have regarding the possibility of over-educating American youth. As long as there is adequate attention to a sound general education, and as long as the occupational or professional education is accompanied by adequate guidance and counselling, the likelihood of any serious overproduction of college preparation seems remote."

However, the subcommittee feels very strongly that the situation calls imperatively for increased emphasis on adequate programs of selection and guidance of engineering college students, so that they may understand the requirements of the profession, the employment opportunities in it, and the possibilities of utilizing an engineering education as a foundation for non-engineering activities.

The last annual report of this Committee recommended "that steps be taken to secure funds so that a carefully laid plan, to develop techniques and methodology, be established in order to secure reasonably accurate and complete statistical information, and that a full-time consultant or statistician be employed to make this complex and difficult survey in that we are confident that it is impossible to make an effective presentation of the facts by the utilization of voluntary personnel of the Society." Since that time, the Bureau of Labor Statistics' report on the Employment Outlook for Engineers has made it evident that this Bureau's studies have gone much further and been more explicit and productive than the preceding studies of the Manpower Committee. The subcommittee therefore recommends that the Manpower Committee be continued as a permanent committee of the Society to work in close liaison with the U. S. Bureau of Labor Statistics.

THE MANPOWER COMMITTEE:

H. H. ARMSBY	S. C. HOLLISTER
M. M. BORING	R. M. KIMBALL
M. T. CARPENTER	C. T. REID
F. M. DAWSON	THORNDIKE SAVILLE
O. W. ESHBACH	W. W. SQUIER
E. P. HAMILTON	T. A. H. TEETER
E. V. HOLLIS	M. W. TRYTTEN

L. M. K. BOELTER, *Chairman*

Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Monday, June 20, 1949, at Rensselaer Polytechnic Institute. Those present were: C. J. Freund, President, F. M. Dawson, B. J. Robertson, Thorndike Saville, S. S. Steinberg, J. S. Thompson, A. B. Bronwell, J. I. Mattill (guest) and D. Daum.

Report of Secretary

The Secretary announced that his written report summarizing the year's activities would be published in the September issue of the JOURNAL. He reported that the membership campaign had resulted in over 1000 new members again this year, of which 122 were industrial executives. A number of university and college presidents have recently joined the Society.

Report of Treasurer

The Treasurer presented the auditor's report as of May 31, 1949. He announced that the Faculty Salary Study Committee account would be closed out shortly after July 1 of the coming year, and that the Southeastern Section is making application for an extension of their research grant.

The Board voted unanimously to authorize the Treasurer to invest $10,000 in the purchase of government bonds.

The Board passed a motion to approve the proposed budget for 1949–50. This budget will be published in the September issue of the JOURNAL.

Appointment of Representative to Pan American Conference

The Board unanimously passed a motion appointing Dean S. S. Steinberg the official representative of the ASEE at the Pan American Engineering Congress to be held in Rio de Janeiro, Brazil, July 15 to 24, 1949. Dean Steinberg's expenses in connection with attending this Congress will be paid by the Brazilian government.

Report of ECAC

Dean Steinberg, Vice-President in charge of the ECAC, reported briefly on the activities of the ECAC. He announced that new by-laws had been approved by the ECAC and the Committee on By-Laws of the Society.

He also announced completion of reports by the following committees:

1. Committee on Engineering Building Survey
2. Faculty Salary Study Committee
3. Manpower Committee
4. Secondary Schools
5. Committee on Military Affairs

These reports were presented at the ECAC General Session. He also stated that the Executive Committee of the ECAC was considering the feasibility of making a new general survey of engineering education, similar to the Wickenden report.

Report of ECRC

Dean Dawson, Vice-President in charge of the ECRC, reported that the 1949 edition of the "Review of Current Research and Directory of Member Institutions" had been completed, and was available for distribution. In the past six months, eight engineering colleges have become members of the ECRC. Also, the Research Council has completed publication of a booklet "Telling the Story of Engineering Research."

1950 and 1951 Annual Meetings

President Freund announced that the annual meeting would be held during the

week of June 19 to 23, 1950, at the University of Washington.

It was moved and seconded to accept the invitation of Michigan State College to hold the annual meeting in 1951 on their campus. The Board recommended that this invitation be presented to the General Council for their approval at the Council meeting on Monday evening.

Fall Meetings, ECAC, ECRC, and General Council

In view of recent correspondence with the Engineering Division of the Land Grant College Assn., the Board voted to accept their proposal to hold meetings of the ECAC, ECRC, Executive Board and General Council on October 28, 1949, at Kansas City, Mo., following the Land Grant College meetings.

James H. McGraw Award

It was voted to recommend to the General Council that the Society accept the proposal for a James H. McGraw Award as outlined in a letter from Mr. Booher of McGraw-Hill Book Company to Mr. Rodes of the Technical Institutes Division, if the proposal be made in writing by the McGraw-Hill Book Company directly to the Society, provided that the Society does not incur any financial obligation in connection with the Award, and subject to the right of the Society to terminate the Award on one year's notice.

An additional motion was passed to recommend to the Council that this Award be handled by the Technical Institutes Division and that the Award be made by and presented at a meeting of the Technical Institutes Division, under conditions to be set by that Division with the approval of the Executive Board.

The above motions were approved, J. S. Thompson not voting.

Publication of the Yearbook

It was moved and seconded that the question of publishing the *Yearbook* in alternate years only be deferred to the next meeting, pending a report and cost estimate from the Secretary on the possibility of reducing the size of type in the *Yearbook* and using two columns to the page.

Applications for Institutional Membership

The following applications for institutional membership in the Society were approved:

Affiliate institutional membership: Academy of Aeronautics, N. Y.; Northrop Aeronautical Inst., Calif.

Associate institutional membership: Tau Beta Pi Assn., Tenn.

Appointment of Secretary

The Board unanimously voted to reappoint Arthur B. Bronwell Secretary of the Society for the year 1949–50.

Distribution of Reports

The Board voted that the Society's policy regarding the distribution of reprints of published reports would be that members may receive one copy of any such reports upon request, but that a charge would be made for additional copies or reprints, the Secretary to determine the amount of the charge in each case.

Speaker's Manual

It was voted to recommend to the General Council that the ECPD be given an opportunity to sponsor jointly the manual "Speaking Can Be Easy," prepared by the Committee on Relations with Industry, if they are interested in this project.

Minutes of General Council Meetings

A meeting of the General Council of the American Society for Engineering Education was held on Monday, June 20, 1949, at the Troy Country Club. Those present were: C. J. Freund, President, M. T. Ayers, G. J. Barker, H. W. Barlow, L. R. Blakeslee, A. B. Bronwell, C. A. Brown, L. E. Conrad, H. O. Croft, D. Daum, F. W. Dawson, M. E. Farris, L. E. Grinter, R. P. Hoelscher, H. K. Justice, W. A. Koehler, F. T. Mavis, O. N. Olson, O. E. Osburn, G. K. Palsgrove, James G. Potter, H. S. Rogers, B. J. Robertson, Thorndike Saville, F. L. Schwartz, S. S. Steinberg, O. M. Stone, J. T. Strate, F. E. Terman (representing E. L. Grant), J. S. Thompson, J. E. Thornton, J. K. Walkup, C. Wandmacher, W. C. White, J. B. Wilbur, J. H. Zant. Invited guests present were: N. W. Dougherty, J. P. Hammond, L. W. Houston, Nell McKenry, L. G. Miller and F. H. Rhodes, Jr.

President Houston welcomed the officers and members of the Society to the Rensselaer campus, and gave a brief history of the founding of Rensselaer Polytechnic Institute and the part it played in the development of engineering education in this country.

Committee on Aims of Engineering Instruction

Dean Hammond presented a proposal for a committee of the Society to study the aims of engineering instruction. The committee would study the effectiveness of various teaching methods, with particular reference to those methods which would increase the student's participation in his own learning process and which would develop to a higher degree the ingenuity, originality, and creative ability of the student. It was voted that copies of Dean Hammond's proposal be mimeographed and made available to members of the Council for further study, and that this question be taken up again at the Friday morning (June 24) Council meeting.

1950 and 51 Annual Meetings

President Freund announced that the dates of the 1950 annual meeting at the University of Washington would be June 19–23. Dean Miller of Michigan State College presented an invitation to hold the 1951 annual meeting during the week of June 25–29 at Michigan State College. The Council voted to accept this invitation for 1951, the exact dates to be determined later.

Secretary's Report

Copies of the Secretary's report were distributed to Council members, and the Secretary commented briefly on the Society's activities during the year.

Report of Treasurer

The Treasurer presented the auditor's report as of May 31, 1949, and announced to the Council that the Board had voted to invest $10,000 in government bonds. Copies of the budget approved by the Board for 1949–50 were distributed to the Council, and this budget will be published in the September issue of the JOURNAL.

Amendments to the Constitution

Professor Croft, Chairman of the Committee on Constitution and By-Laws, presented the proposed amendments to the Constitution. After some discussion, a straw vote was taken on the proposed amendment to present Article XI, Section 2, to determine whether the nominating committee should include the retiring Council members representing both Divisions and Sections or only those repre-

senting Sections. It was voted that this proposed amendment should specify that both Division and Section representatives be included on the Nominating Committee.

The amendments submitted by the Committee on Constitution and By-Laws, as revised by the above vote, were approved. These amendments will be submitted to the general membership of the Society for final vote.

Provisional Division Status for Committee on Relations with Industry

The Council voted to grant Division status to the Committee on Relations with Industry, subject to approval of the proposed Constitutional Amendments by the Society membership.

Report on Activities of Divisions and Committees

Vice-President Saville presented a brief report on the activities of the Divisions and Committees. He pointed out that the chairmen of the various Divisions and Committees were kept informed of activities of the Society through circular letters. He reemphasized the need for Committees and Divisions giving consideration to initiating long-range projects which will contribute to the fundamental objectives of the Society.

Report on Sections and Branches

Vice-President Robertson presented a brief report on activities of Sections and Branches, indicating that several new branches have been established where needed. It was voted to approve the requests of the University of Arkansas to join the Missouri Section, and of the University of Utah and Utah Agricultural College to join the Rocky Mountain Section.

Measurement and Guidance Project.

President Rogers presented a progress report of the Measurement and Guidance Project now being administered by the Educational Testing Service. He stated that, as presently constituted, there appears to be little likelihood that the project can be put on a self-financing basis and that some form of reorganization may be necessary. One proposal being considered is that of merging the Measurement and Guidance tests with the College Entrance Board tests.

Journal

The Secretary reported that many favorable comments have been received on the new cover layout and format of the JOURNAL. The possibility of achieving an economy by publishing the *Yearbook* in smaller type size was suggested by the Treasurer and will be investigated. The inclusion of a page in each issue of the JOURNAL giving the dates and location of Section meetings has proven of considerable value and will be continued. Also a page will be set aside in each issue for the use of Divisions. No increase in printing costs is anticipated for the coming year, although a bill now before Congress would increase the cost of postage rates, and add about $2300 to the cost of mailing the JOURNAL.

Section Rebates

The question of increasing the membership dues and making corresponding rebates to Sections was raised. It was pointed out that most Sections have only one meeting a year and that the operating costs are consequently relatively small and are usually carried either by the host institution or by a slight increase in the cost of meals. It was also pointed out that a constitutional provision specifies that Sections shall be self-sustaining, a provision which was included in order to keep the Society dues to a minimum. In view of these considerations, no action was taken on the proposal.

The Council meeting was adjourned and the other items on the agenda were deferred until the Friday morning meeting on June 24.

* * *

MEETING, JUNE 24, 1949

A breakfast meeting of the old and new members of the Council was held on Fri-

day, June 24, 1949, at the Hendrick Hudson Hotel, Troy, New York. Those present were:

C. J. Freund, President, H. H. Armsby, M. T. Ayers, H. W. Barlow, H. R. Beatty, C. E. Bennett, A. B. Bronwell, C. A. Brown, L. E. Conrad, D. Daum, F. M. Dawson, M. E. Farris, L. E. Grinter, G. B. Hoadley, R. P. Hoelscher, W. L. Hughes, H. K. Justice, W. A. Koehler, J. H. Koffolt, R. D. Landon, L. J. Lassalle, F. J. Lewis, G. D. Lobingier, E. R. McKee, O. N. Olson, O. E. Osburn, G. K. Palsgrove, J. G. Potter, B. J. Robertson, M. B. Robinson, Thorndike Saville, S. S. Steinberg, O. M. Stone, J. T. Strate, J. S. Thompson, J. E. Thornton, C. Wandmacher, W. C. White, R. Z. Williams, J. H. Zant. Invited guests present were: H. P. Hammond, Nell McKenry and F. H. Rhodes, Jr.

Life Membership

The following applications for life membership were approved, and the Secretary was instructed to notify these members of this action:

Robert M. Black	Almonte C. Howell
James E. Boyd	L. L. Patterson
John A. Ely	O. W. Silvey
Leroy S. Foltz	

Delinquent Members

The Secretary was authorized to drop from membership in the Society those who are in arrears more than two years in dues.

Committee on Ethics of Interviewing Procedures

It was voted that when the Committee on Relations with Industry becomes a Division as provisionally voted at the Monday Council meeting, then the Committee on Ethics of Interviewing Procedures shall become a subcommittee of the Division on Relations with Industry.

Committee on Aims of Engineering Instruction

It was voted that the plan for a committee on aims of engineering instruction, as outlined in the letter by Dean Hammond distributed to Council members, be adopted and that a steering committee be appointed. It was further voted that this steering committee should formulate its objectives and then contact the Divisions and Committees in similar fields for nominations of additional committee members. Additional appointments would then be made to the enlarged committee by the President of the Society and this committee would then become a committee of the Society. It was suggested that the Council members write to President-elect Saville informing him of any suggestions they might have for the membership of this committee.

Professor Grinter reported that he will be writing to the President proposing a similar committee to work on graduate study.

Enrollment Statistics

The Council voted to approve an agreement with the U. S. Office of Education, whereby the Society and the Office of Education will work jointly in the collection and tabulation of engineering enrollment statistics. The tabulation will be handled by the U. S. Office of Education. This agreement was previously approved by the Executive Board of the ASEE and the Office of Education.

Summer Schools

President-elect Saville announced that plans for future summer schools would be discussed at the meeting of Division and Committee Chairmen to be held later in the day, in order to obtain advance planning and better organization of the summer schools.

Technical Institute Award

The Executive Board's recommendations regarding the James H. McGraw Award, recommending acceptance of this Award with certain provisions, was approved by the General Council.

Geographical Rotation of Annual Meetings

The Secretary called the Council's attention to the plan for a geographical rotation of annual meetings which was adopted by the Executive Board and briefly explained the plan. This plan divides the country into six zones, based upon membership population, and assures that each zone will have an annual meeting at least once every eight years.

The Chairman of the Electrical Engineering Division commented on the conflict between the ASEE and AIEE meeting dates. Attempts are being made to minimize such conflicts wherever possible and to coordinate the meetings of engineering societies having conflicts so as to make it possible for Society members to attend meetings of more than one engineering society. However, it has been found necessary for the ASEE meetings to be held at a time which is convenient to the host institution, which is usually the third or fourth week of June since this falls between terms. There are four other major engineering societies which hold their annual meetings during these two weeks, and it appears as though a conflict is inevitable, unless one or more of the societies changes its basic plan of summer meetings. The suggestion was made that the ASEE might hold one of its annual meetings in the South at Xmas time in order to avoid such conflicts. This matter will be studied by the Executive Board.

Speaker's Manual

It was voted that the Society should approach the ECPD to determine whether or not they would be interested in jointly sponsoring the publication of the Speaker's Manual which was prepared by the Committee on Relations with Industry.

National Science Foundation Appointments

The Council voted to adopt the following resolution regarding the National Science Foundation Bill:

RESOLVED, that

WHEREAS, the engineering profession and engineering educators have a vital interest in government sponsored engineering research as embodied in the National Science Foundation Bill, and

WHEREAS, it is deemed imperative to the nation's welfare to have engineers represented on the governing board of the National Science Foundation,

THEREFORE BE IT RESOLVED, that the General Council of The American Society for Engineering Education authorize the Executive Board of this Society, in cooperation with other engineering societies, to make nominations for members of the governing board of the National Science Foundation.

The meeting was adjourned at 9:30 A.M.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

Fifty-Seventh Annual Meeting
American Society for Engineering Education

The Fifty-seventh Annual Meeting of The American Society for Engineering Education was held at Rensselaer Polytechnic Institute, Troy, New York, June 20–24, 1949. Over 1750 members and guests were registered, this being the largest attendance in the history of the Society. Four general sessions and approximately ninety conferences of Councils, Divisions, and Committees were held. C. J. Freund, President of the Society and Dean of Engineering at the University of Detroit, presided.

The first general session on Tuesday morning was opened by President Freund who introduced L. W. Houston, President of Rensselaer Polytechnic Institute, who welcomed the Society to Rensselaer. He spoke on administrative problems facing the universities and colleges, with particular emphasis upon the financial problems. Vice-President Robertson, as presiding officer, then introduced President Freund, who delivered the address on "Engineering Education and Freedom from Fear." A certificate was presented by E. S. Burdell to President Houston of Rensselaer Polytechnic Institute extending the Society's congratulations to Rensselaer on their 125th Anniversary. M. E. Coyle, Executive Vice President, General Motors Corporation, spoke on "Maintaining Our Industrial Leadership through Engineering."

The second general session on Wednesday morning was presided over by Vice-President F. M. Dawson, Chairman of the Engineering College Research Council, who reported on the activities of the ECRC for the year. The program featured the subject "Instrumentation for Engineering Research," with an address by G. S. Brown of the Massachusetts Institute of Technology, and other short talks on research equipment by panel speakers. An interesting demonstration of research instruments and equipment followed the General Session.

The third general session on Thursday morning was opened by Vice-President S. S. Steinberg, Chairman of the Engineering College Administrative Council. The following papers were presented:

1. Educational Testing Service—O. W. Eshbach
2. Summary Report of Committee on Manpower—H. H. Armsby
3. Engineering Mission to Latin-America—S. S. Steinberg
4. Engineering and Technical Education in Great Britain from 1929 to 1949—W. R. Woolrich
5. Report of Salary Study Committee —W. C. White

The annual dinner was held Thursday evening with President Freund presiding. The speaker was The Honorable George V. Allen, Assistant Secretary of State, who spoke on "Where Do We Stand on Point Four," with particular reference to the part which engineers will take in President Truman's proposed Point 4 Program dealing with international exchange of technical information. President Freund then introduced the officers of the Society and the chairman of the local committee. President L. W. Houston of Rensselaer Polytechnic Institute presented Freund with a gravel made from the wood of a replica of the original "Half Moon," Hendrick Hudson's famous ship.

The Lamme medal was presented to Karl T. Compton, Chairman of the Research and Development Board and

Chairman of the Board of Directors of the Massachusetts Institute of Technology, and the George Westinghouse Award to Joseph Marin, Professor of Engineering Mechanics at Pennsylvania State College.

Past President Rogers, Chairman of the Nominating Committee, presented the following slate of officers. Upon motion, they were unanimously elected.

For President, one year: Thorndike Saville, New York University.

For Vice-President in charge of instructional division activities, to fill out the unexpired term of Thorndike Saville for one year: B. J. Robertson, University of Minnesota.

For Vice-President in charge of sections and branches, two years: H. H. Armsby, U. S. Office of Education.

For Treasurer, one year: James S. Thompson, White Plains, N. Y.

At an election of the Engineering College Administrative Council, F. E. Terman, Dean of Engineering at Stanford University, was elected Vice-President of the Society in charge of the Engineering Colleges Administrative Council. The Society's Vice-President in charge of the Engineering College Research Council, F. M. Dawson, Dean of Engineering at the State University of Iowa, continues in office for another year.

President Freund announced that the 1950 annual meeting would be held at the University of Washington, June 19–23, and that the 1951 annual meeting would be held at Michigan State College.

The fourth general session on Friday was under direction of the Committee on Relations with Industry. Vice-President Thorndike Saville presided at this meeting. The following papers were presented:

1. Industry-College Relations—The Role of the Practicing Engineer—L. A. Appley
2. Industry-College Relations—The Role of the Engineering Educator—R. Walters
3. Factors Affecting Industrial Activity—C. H. Greenewalt

In addition to the general sessions and conferences, the Annual meeting included several outstanding features aimed at contributing to the advancement of engineering education. An industry-college forum, sponsored by the Committee on Relations with Industry, on the subject "Development of the Young Engineer," attended by over 200 industrialists and administrators of engineering colleges, presented nationally prominent speakers on subjects dealing with the professional development of the young engineer, licensing of engineers, and union aspects of engineering.

An unusually successful exhibit of instructional aids, arranged by a committee on Visual Aids under the Educational Methods Division, served to disseminate ideas on the application of visual aids to engineering instruction. The exhibit included many ingenious devices for illustrating fundamental principles in mechanics; devices for demonstrating field and flow patterns in complicated electric fields, magnetic fields, heat flow and fluid flow fields; devices for illustrating wave phenomena; and many other interesting exhibits, as well as films and slides on engineering subjects. This exhibit clearly demonstrated the potentialities of applying visual aids to engineering instruction and has served to stimulate increased effort in the construction and use of instructional aids. A similar exhibit is being planned for the Annual Meeting next year at the University of Washington.

Another unusual feature of the Annual Meeting was an International Night Dinner and Conference. Arranged by the Society's Committee on International Relations, this meeting was attended by over forty engineering administrators and educators from foreign countries, in addition to many U. S. members of the Society. The various foreign delegates spoke briefly upon the background and present status of engineering education in their respective countries.

The following resolution of thanks to Rensselaer Polytechnic Institute was read

at the banquet by H. W. Barlow, Chairman of the Committee, and unanimously approved by the Society:

"To the Rensselaer Polytechnic Institute and to the many local committees through which excellent arrangements were made and executed, The American Society for Engineering Education on this occasion of its Fifty-Seventh Annual Meeting wishes to express its appreciation and thanks.

"The hospitality, courtesy, and kindness of the staff members of our host institution have been thoughtful and generous; the arrangements for meetings and conferences have shown careful and efficient planning. The entertainment provided for us, our wives and families and the opportunities for us to see this beautiful and historic part of our nation will be remembered with pleasure.

"It is especially gratifying to have had the opportunity of participating in the celebration of the One Hundred and Twenty-Fifth Anniversary of engineering education at this institution.

"Grateful thanks are also extended to the industries of the regions for arranging interesting and instructive inspection trips.

"To the officers and committees of The American Society for Engineering Education who have guided so successfully this organization through the past year, and have directed its growth and substantial contributions to the education of our young people, the Society extends its highest congratulations and approval."

The annual meeting adjourned sine die to meet at the University of Washington, Seattle, Washington, June 19–23, 1950.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

Reserve these dates . . .

E.C.A.C. and E.C.R.C. MEETINGS

Kansas City — October 28, 1949

Kansas City Municipal Auditorium, Room 600

. . . and

ANNUAL MEETING

June 19–23, 1950

UNIVERSITY OF WASHINGTON

Seattle, Washington

Principles Which Should Guide the Development of an Undergraduate Program in Engineering

By THE COMMITTEE ON UNDERGRADUATE CURRICULA

This statement has been prepared with particular reference to undergraduate curricula in Civil Engineering. It is clear, however, that the basic arguments, principles and recommendations advanced apply with equal force to all undergraduate engineering programs.

General Considerations

We believe that the following general facts must form the basis for the further development and evolution of undergraduate curricula in engineering.

1. Any satisfactory undergraduate engineering course must be planned, organized and staffed so as to blend into a well-coordinated and integrated whole, four groups of studies:

a. *General education* with special attention to the effective oral and written use of English, to awakening the students' interests in man's hopes and aspirations, his aims and his problems, as revealed in the written word, and, especially, to the part which the engineer, both as a citizen and in the interests of his profession, must play in the efforts of man to cope with the economic, social and political problems of an adaptive society in an age of ever more rapid technological change.

b. *Mathematics and natural science.* It is inevitable that undergraduate engineering education must continue to give increasing emphasis to a thorough training of the young engineer in the understanding and use of these basic tools of his profession.

The trend in engineering practice has, for close to a century, been toward the ever-increasing rationalization along mathematical and scientific lines of design techniques which formerly were based on empirical practices or rules-of-thumb. This search for the "reduction to a science" of older practices goes forward today at an ever-greater tempo.

Furthermore through research in both natural and engineering science, older understandings are being strengthened while new discoveries constantly create new techniques and avenues for further progress.

c. *Basic engineering science,* including the mechanics of materials, engineering thermodynamics, hydraulics or fluid mechanics, the principles of power machinery, and of electric machines and circuits.

These subjects are basic to any sound undergraduate program not only because they introduce the student to the viewpoint and methods of engineering (the "engineering mind"), as contrasted with natural science, not only because they find application and use in all branches of engineering, but because the young engineer frequently follows a branch of engineering other than that of his undergraduate study.

d. *Specific technological applications.* An introduction to some of the problems of application and use of the foregoing studies in a specific major field of engineering and the special practices and techniques involved. The undergraduate student cannot be left with a great collection of tools which he does not understand how to use. Some courses in specific techniques of practice are essential if his feet are to be kept on the ground

and he is to be prepared for effective subprofessional service.

While it is true that many of the basic principles of engineering practice are common to all branches of engineering—such as chemical, civil, electrical, industrial, mechanical or mineral—a single "general engineering" curriculum based on this observation would not afford a practical and realistic solution of our present day undergraduate situation. The trend, we believe, is in this direction but these principles can be developed and the techniques of applications can be quite as effectively taught in any one of these major branches as in another and far more usefully than in a general engineering course.

We favor, therefore, the maintenance of these older and well-established divisions in this fourth group of studies. On the other hand we are opposed to any further undergraduate specialization through many options or electives because it must inevitably lead to less emphasis on the fundamentals of all engineering education comprised in groups (a), (b), and (c).

Length of Curriculum

2. Four years has been the long established period for the first or bachelor's degree. We agree that four years do not afford sufficient time if all the subjects of the older four-year curricula are to be retained in new programs which must now include due attention to the general educational group of subjects plus increasing emphasis on mathematics and science, both natural and engineering.

In our opinion, the time has arrived when we should give attention to the long-expressed viewpoint that undergraduate engineering education should be limited to fundamentals and that any marked specialization should be deferred to graduate study.

We believe that the statement cannot be disputed, that any engineering graduate who is well grounded in the fundamentals can, through self-study during his engineering apprenticeship, or through specialized post-graduate education, make good on almost any specialized branch of engineering application. On the other hand, it is very rare indeed that the student who lacks in fundamental understandings is ever able later to make good in the basic omissions of his undergraduate years.

The time has come for a complete overhauling of the traditional programs in all branches of undergraduate engineering education with more than lip service to fundamental needs and objectives in mind.

Specific Recommendations

3. In order to make effective the above proposals it will be necessary to eliminate from undergraduate curricula a number of subjects which, in the past, have been considered as "something the young engineer could not do without." Many engineering teachers have devoted their careers to, and achieved their reputations as experts in some of these more highly specialized—and too often largely descriptive—subjects. Many of them constitute excellent vehicles of engineering education. Yet as we have said, four years should be long enough for a sound, fundamental engineering course—to make it so, eliminations in group (d) must be the answer.

We therefore recommend

1. That all undergraduate options in the major branches of engineering be omitted—to be specific, such options in civil engineering as aeronautical, highway, municipal, railroad and sanitary engineering. We recommend a single fundamental undergraduate B.S. course for all civil engineering students irrespective of their specialized interests or ambitions.

2. That subjects largely descriptive in character such as the details of highway construction, railroad operation and maintenance, the detailed design of water supply and sewage systems, the older type of courses in foundations, descriptive courses in materials, etc. be either entirely

eliminated from the undergraduate program or very radically curtailed.

3. That in the undergraduate program the division of time devoted to the four groups of studies above noted (*i.e.* a, b, c, and d) be substantially equal.

4. That, in the selection of suitable subjects in group (d), special attention be given to thorough grounding in those subjects—such as statically indeterminate analysis, basic work in the limitations of common theories and the principles of the theory of elasticity, soil mechanics, hydraulics and hydrology—which the student cannot secure without effective guidance. Furthermore, that those courses be selected as vehicles for instruction in the basic principles of civil engineering practice which best exemplify the interaction of the various factors of need and demand and the economics of design, construction, and operation, and for which qualified staff of broad interests and experience is available. In other words, we do not feel that any rigid selection in this latter area is desirable but that, on the contrary, it should reflect the special interests and staff abilities of the individual school.

Finally we urge that every possible effort be made to secure the successful and effective development of the four groups of subjects comprising the undergraduate curriculum into a well-coordinated and integrated whole. These are not four independent and unrelated groups of study. The divisions which exist are solely for the purpose of providing an organized sequence of studies and distributing teaching duties. Without full cooperation and integration such an engineering course becomes a hodge-podge of unrelated disciplines and its true educational value is completely lost.

While parts of the reports refer particularly to civil engineering, the basic ideas apply equally well to chemical, electrical, mechanical, metalurgical, and mining engineering and other branches.

One subcommittee member takes exception to the section on options. A member of another committee comments as follows:

". . . one of the problems that seems to me in line for discussion in mineral engineering curricula is the need for appreciation on the part of students that it is not sufficient for them to have nurtured *ideas* while in college and to have learned to deal with *things*. Much of their progress in a professional way will depend not on their having ideas nor on their knowledge of material systems, but upon their ability to work for *people*, with people, and to get people to work for them. This kind of knowledge requires a perception of the well-springs of human nature, a perception that youth is not likely to develop.

Courses designed to increase knowledge in this field are bound to be very difficult to teach effectively. On the other hand, it seems to me that it should be possible to make college students realize that this is the most important activity that they will have to enter into professionally or otherwise in their adult life, and that they must be prepared to continue to go to school after they graduate with this topic of human understanding and human relations as a cardinal objective of their professional development. Certainly, people are not placed in managerial positions unless they are able to keep harmony in human relations. At least when a man is selected for the assignment, he is selected on the grounds that he appears to be the best to accomplish this happy result, and at the same time has an adequate knowledge of the things and ideas involved to carry the enterprise forward effectively."

. . .

However, with this one exception, all members of the committee of 23 endorse and approve the report.

At the suggestion of President Freund, the following questionnaire was submitted to 138 institutions, either to the Dean of Engineering or Director, as the case might be. To date, 93 replies have been received:

"Would you care to answer a very simple questionnaire? To what extent has the design of the various curricula in engineering in your institution been affected by the following reports of either S.P.E.E. or A.S.E.E.? In each case simply note significant changes, if any.

1. "The Investigation of Engineering Education."
2. "Aims and Scope of Engineering Curricula."
3. "Engineering Education After the War."
4. Note other reports of the society which have influenced decisions, and in what way.
5. Are your procedures at variance with committee reports of the society? If so, in what significant respects?

To summarize the situation, it may be stated that there is no shadow of doubt but that the articles mentioned have had profound and deep effect on the vast majority of the institutions regarding the setup of the various curricula in engineering. However, it is also true that a few institutions claim that they have not been influenced by these reports and have originated their own plans. However, no Dean or Director has stated categorically that their procedures are at variance with these various reports, except that quite a number of institutions have gone on the five-year plan, following the trend of emphasis on fundamentals, and placing highly specialized work in a graduate program or a fifth year; and also, making room for desirable humanistic and social studies. The replies from the various institutions are on file in the Office of the Chairman, and would be available on a loan basis if desired and if approved by President Freund.

The Committee consists of the following:

D. L. Arm
J. K. Finch
A. M. Gaudin
E. Hutchisson
W. N. Jones
J. H. Lampe
R. F. Mehl
E. M. Schoenborn
R. L. Sweigert
P. Cloke, *Chairman*

In the News

A "Directory of Secondary Schools in the United States," just issued by the **Federal Security Agency**, lists public and private schools in every state, the District of Columbia, and the Territories, and furnishes information on each school's accreditation status, number of students and graduates, number of teachers, and other facts. The directory, prepared by the Office of Education, is the most comprehensive guide to information about high schools in the United States ever issued. It lists by name more than 27,000 secondary schools of all organization types, including junior high schools.

Copies are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., as Office of Education Circular No. 250. The price of a single copy (496 pages) is $1.50.

A gift of $1,000,000 from Alfred P. Sloan, Jr., Chairman of the Board of the General Motors Corporation, has been received by the **Massachusetts Institute of Technology** for construction of a Metal Processing Laboratory building.

The gift is part of the total of $5,100,000 received by the Institute during the last year, according to Dr. James R. Killian, Jr., President of M.I.T. The total includes numerous grants-in-aid from industrial companies, all of which expect indirect returns through the strengthening and broadening of the Institute's program of research and education.

The **California Institute of Technology's** new $407,000 Earhart Plant Research Laboratory, science's nearest approach to a "weather factory" in which all types of climatic conditions can be man-made for study of their effects on plant growth, will be dedicated on June 7, it was announced today.

Progress Report on ECPD Activities

At a meeting of the Executive Committee of the Engineers' Council for Professional Development on May 23, 1949, H. T. Heald, President of Illinois Institute of Technology and Chairman of the Committee on Engineering Schools of the ECPD, announced that 106 engineering colleges have been visited by inspection committees during the past two years. A total of 481 curricula have been inspected, including 112 new curricular inspections. It is anticipated that by the end of the inspection year a large share of the previously accredited curricula will have been reviewed and virtually all new curricula for which inspection has been requested will have been examined.

The Committee on Engineering Schools is also studying the accreditation of graduate work in engineering. It is also attempting to develop better procedures for handling specialized engineering curricula.

The Committee on Professional Training, headed by A. C. Monteith, vice-president of Westinghouse Electric Corporation, is embarking upon a seven-point program, focusing attention upon improving the professional training in the post-graduation years. This program includes:

(a) a comprehensive survey of post-graduate programs in engineering colleges, industry, the government, and engineering societies;
(b) a study of methods of developing community-level programs aimed at improving the professional status and training of the engineer;
(c) an analysis of the professional registration of engineers;
(d) the encouragement of personal appraisal of the engineer in relation to his job, his community, and the engineering profession;
(e) a study of orientation and training programs in industry, with a view toward disseminating information along this line which will aid both large and small companies in developing suitable programs;
(f) the revision of selected bibliographies of engineering subjects; and
(g) the preparation of a selected reading list for young engineers. The latter two projects are nearing completion.

The Committee on Professional Recognition of the ECPD, headed by Ole Singstad, has prepared a report on uniform grades of membership in engineering societies and minimum qualifications for each grade of membership.

The membership grades recommended by the Committee include:

(1) member
(2) associate member
(3) student member

In addition, it was recommended that the optional grades of "fellow" and "affiliate" be included.

The recommendations of the Committee have not been finally approved by the ECPD, but will be considered at its Executive Committee meeting on July 28. If approved and adopted by the participating societies, this action will serve to unify the grades of membership in the various engineering societies so as to avoid the confusion which exists at the present time resulting from non-uniformity in membership grades.

The next Annual Meeting of the ECPD will be held at the Edgewater Beach Hotel in Chicago on October 28 and 29, 1949.

THE T-SQUARE PAGE

Officers
O. W. Potter, *Chairman*
C. H. Springer
T. T. Aakhus
C. J. Vierck
R. T. Northrup
R. P. Hoelscher

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

W. J. LUZADDER, *Editor*
Purdue University

Officers
I. L. Hill
R. S. Paffenbarger
J. G. McGuire
W. E. Street
C. E. Rowe
H. C. Spencer

We take the liberty of publishing a letter recently received from the Dean of one of our Colleges of Engineering. The letter was written in reply to our request for a statement along the line of some remarks he had made at an informal meeting last winter.

"Dear Professor Luzadder:

It is with a very real feeling of diffidence that I reply to your request for a contribution to the pages of the "T-Square" because I am not a teacher of engineering drawing and cannot claim competence in any branch of the subject. Maybe that fact alone will qualify me to write in answer to your kind invitation, certainly I can *not* be accused of bias!

I think that engineering drawing is one of the most important subjects of the curriculum in the education of the engineer, for several good reasons. Among them are:

a. It is an indispensable tool of the engineer throughout his life, even if he never practices engineering. How many times has one been delighted with an accurate, easily understood sketch of a wholly non-engineering subject and quite removed from all technical atmosphere? It can be made to supplant many lines of written description—may even be read and understood by one with no medium of spoken words.

b. It is incomprehensible how one can gain any knowledge of science and engineering without the use of proper diagrams, drawings, sketches, etc., to say nothing of mapping. We can imagine commerce getting along without shorthand, but not engineering work without drawing!

c. Coming early in the various curricula, drawing serves to bring the new student close to a realization of his objective in trying to fit himself for his career. Possibly many teachers of engineering drawing do not realize the special opportunity they have in beginning to nurture this idea of "career" in the beginning student. Particularly is this true if the teacher can draw from his own experience as an engineer and point up his dicta by apt references to the usefulness of the work as it unfolds.

d. One of the most helpful attributes of a properly taught course in engineering drawing is that of discipline. If I may be pardoned a personal reference, engineering drawing was one of the most difficult subjects I had in my college work; not because I did not understand it (with reasonable diligence, even descriptive geometry made good sense to me) but it was the necessity of being neat and accurate! My own clumsiness was more difficult than the ideas of "upness and downness, frontness and backness, rightness and leftness." But I was *compelled* (and I mean with a capital C) to learn to start and stop at the right place! Since we must all agree that discipline is a watchword in the education of the engineer, I don't know of a better place to include it than in the drawing room.

And finally, may I say let us never unwisely economize with the talent we have in our Drawing Departments. There may be places where the idea prevails that the highest quality of personnel is not necessary for the Drawing Department, but thank goodness that place is not this College!"

New Members

AJAX, FRED W., Associate Dean of Students, Georgia Institute of Technology, Atlanta, Georgia. R. L. Sweigert, R. S. Howell.

ALBRECHT, CARL F., Assistant Professor of Agricultural Engineering, Michigan State College, East Lansing, Mich. H. P. Skamser, H. L. Aldrich.

ALLMAN, JAMES M., Assistant Professor of Mechanical Engineering, University of Delaware, Wilmington 11, Del. D. L. Arm, F. Zozzora.

ARNOLD, ISAAC, Vice President, Quintana Petroleum Corporation, Houston, Texas. C. J. Freund, A. B. Bronwell.

BAHME, CHARLES W., Engineering Ext. Div. Inst., University of California, Los Angeles 34, Cal. C. J. Freund, A. B. Bronwell.

BEERS, NORMAN R., Editor, Nucleonics, McGraw-Hill Publishing Co., New York 18, N. Y. J. W. Wight, H. P. Graves.

BELL, NORMAN, Assistant Professor of Chemical Engineering, University of Pittsburgh, Pittsburgh 13, Pa. A. B. Bronwell, Kuo Tsung Yu.

BLADE, MARY FRANCES (MRS.), Assistant Professor of Engineering Drawing, The Cooper Union School of Engineering, New York, N. Y. C. H. Young, J. H. Peterson.

BONN, ROBERT, Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh 32, Pa. W. I. Short, J. R. Smith.

BOUTWELL, FREDERICK K., Instructor in Mechanical Engineering, Duke University, Durham, N. C. C. B. Vail, R. E. Lewis.

BOYD, JAMES S., Assistant Professor of Agricultural Engineering, Michigan State College, East Lansing, Mich. C. L. Brattin, A. B. Bronwell.

BRUSH, EDWARD E., Head, Aeronautical Engineering Department, Texas A. & M. College, College Station, Texas. R. P. Ward, J. D. Lindsay.

BURCHARD, JOHN E., Dean of Humanities, Massachusetts Institute of Technology, Cambridge 39, Mass. T. K. Sherwood, L. L. Moreland, E. S. Burdell, R. S. Bowman.

BUSH-BROWN, HAROLD, Director, School of Architecture, Georgia Institute of Technology, Atlanta, Ga. A. B. Bronwell, C. J. Freund.

CAMP, WILBUR E., Instructor in Civil Engineering, Purdue University, Lafayette, Indiana. A. B. Bronwell, G. P. Springer.

CANNING, ROBERT V., Instructor in Electrical Engineering, University of Delaware, Wilmington 11, Del. D. L. Arm, Frank Zozzora.

CANTLUPE, VICTOR J., Special Lecturer in Mechanical Engineering, Newark College of Engineering, Newark, N. J. H. E. Walter, J. L. Polaner.

CARMICHAEL, LEONARD, President, Tufts College, Medford 55, Massachusetts. C. J. Freund, A. B. Bronwell.

CARVER, WILLIAM O., Draftsman and Instructor in Agricultural Engineering, Michigan State College, Lansing, Mich. H. P. Skamser, H. L. Aldrich.

CASHMAN, ROBERT D., Director of Placement, Rhode Island State College, Kingston, R. I. T. S. Crawford, A. B. Bronwell.

CAVANAUGH, JOHN J., President, University of Notre Dame, Notre Dame, Indiana. C. J. Freund, A. B. Bronwell.

CHASE, ARTHUR S., Associate Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. T. M. Lowe, A. L. Thomas.

CHURAK, ANTHONY P., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. W. J. Short, J. D. Dinker.

CLEMENT, STUART H., Supervisor of Senior Placement and Associate Director, Student Appointment Bureau, Yale University, New Haven, Conn. W. J. Wohlenberg, F. R. Hughes.

COSSA, JOHN A., Associate Professor, Education, General Guidance Director, Manhattan College, New York 63, N. Y. Brother Aubert, Brother A. Leo.

CRAIGIE, LAURENCE C., Commandant, USAF Institute of Technology, Dayton, O. E. Kotcher, J. H. Belknap.

CULBERTSON, WILLIAM W., Associate Professor of Metallurgy, Case Institute of

Technology, Cleveland 6, O. O. M. Stone, E. W. Oberzil.

DAMODARAN, GOVINDASWAMY R., Director, Electrical and Mechanical Engineering Education, P. S. G. Industrial Institute, Coimbatore, India. A. B. Bronwell, C. J. Freund.

DAVIS, CHARLES M., Assistant Professor of Petroleum Engineering, Missouri School of Mines, Rolla, Mo. C. L. Wilson, J. D. Forrester.

DAVIS, PEARCE, Chairman, Departments of Business and Economics and Industrial Engineering, Illinois Institute of Technology, Chicago 16, Ill. H. C. Spencer, E. G. Paré.

DAWSON, JOHN D., Director, Personnel Department, Antioch College, Yellow Springs, O. G. E. Owen, C. D. Barbulesco.

DORR, JOHN V. N., Chairman of Board, The Dorr Company Engineers, New York, N. Y. A. B. Bronwell, C. J. Freund.

DRAUGHON, RALPH B., President, Alabama Polytechnic Institute, Auburn, Ala. A. B. Bronwell, C. J. Freund.

DRIFTMIER, RUDOLPH H., Head, Agricultural Engineering Department, University of Georgia, Athans, Ga. C. J. Freund, A. B. Bronwell.

DUNKERLEY, PAUL A., Instructor in Civil Engineering, Tufts College, Medford, Mass. P. S. Rice, W. W. Fagan.

DUNLEVEY, DAVID B., Recruiting and Training, Ind. Rel. Div., Buckeye Cotton Oil Company, Memphis, Tenn. E. B. Norris, M. M. Boring.

ENELL, JOHN W., Instructor in Administrative Engineering, New York University, New York, N. Y. J. M. Juran, T. Saville.

ENGLER, KYLE, Head, Agricultural Engineering Department, University of Arkansas, Fayetteville, Ark. G. F. Branigan, R. G. Paddock.

ETTORRE, JAMES E., Instructor, Mechanical Engineering, Bridgeport Engineering Institute, Bridgeport 5, Conn. S. R. O'Meara, L. B. Curran.

FAIRBANKS, ANDREW J., Professor of Aeronautical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. P. E. Hemke, S. Mackay.

FURLONG, JAMES W., Asst. Coordinator, University of Detroit, Detroit 21, Mich. H. Gudebski, C. J. Robert.

GERMANO, FRANK J., Professor of Engineering Mechanics, Louisiana State University, Baton Rouge, La. O. J. Baker, A. B. Bronwell.

GLOCKLER, GEORGE, Head, Dept. of Chemistry and Chemical Engineering, State University of Iowa, Iowa City, Iowa. J. O. Osburn, H. O. Croft.

GOLDMAN, STANFORD, Professor of Electrical Engineering, Syracuse University, Syracuse, N. Y. C. E. Tucker, K. L. Wildes.

GOTTSCHALL, CLARENCE R., Assistant Professor in Mechanical Engineering, University of Delaware, Wilmington, Del. D. L. Arm, F. Zozzora.

GREAVES, JOHN D., Representative, Publishing Dept., International Textbook Co., Scranton, Pa. F. H. Dunlap, W. W. Scranton.

GRECCO, WILLIAM L., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh 6, Pa. W. I. Short, J. D. Dinker.

GUENVER, JAMES L., Instructor in Electrical Engineering, University of Delaware, R. D. Newark, Del. D. L. Arm, F. Zozzora.

HALSEY, JAMES F., Research Assistant Professor of Fluid Mechanics, Theor. and Appld. Mech., University of Illinois, Urbana, Ill. C. S. Camp, W. P. Wallace.

HERSHKOWITZ, BERNARD H., Assistant Instructor in Mechanical Engineering, Newark College of Engineering, Newark 8, N. J. R. E. Bannon, T. A. Schneider.

HOFFMAN, LESLIE A., Dean, Head of Mechanical Engineering Dept., Bridgeport Engineering Institute, Bridgeport, Conn. S. R. O'Meara, T. B. Curran.

HOUSTON, WILLIAM V., President, Rice Institute, Houston, Texas. C. J. Freund, A. B. Bronwell.

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TURNER, LOUIS A., Head, Physics Department, State University of Iowa, Iowa City, Iowa. C. J. Freund, A. B. Bronwell.

VAN DER ROHE, LUDWIG M., Director, Department of Architecture, Illinois Institute of Technology, Chicago 16, Illinois. C. J. Freund, A. B. Bronwell.

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Toiling in the Night

By B. J. ROBERTSON

Vice President of the ASEE and Professor of Mechanical Engineering, University of Minnesota

If one of us were asked the question "Who speaks for your schools?", he would undoubtedly reply "Why the President is the only person who has such authority." But many visitors have talked to no one except building custodians, whom they ask for directions, or a clerk in some office, or a student. So far as these visitors are concerned the courtesy, interest, or friendliness expressed by any one of these people reflects the character of the institution. A snippy clerk, a grouchy janitor, a smart-aleck student, may be responsible for the impression made upon the visitor and it is they, unfortunately, who then speak for the school.

Since the ASEE has no physical plant, no janitors, no students, all of the personal contacts for the Society are made by its individual members. The president, the vice presidents, the secretary and his office staff contact relatively few of the large number of people who have interests in common with the Society.

Those who participate in meeting programs, local, regional, or at the annual meeting, contact more people. But with the all-high record of attendance at the annual meeting at Rensselaer Polytechnic Institute, only about 20% of the total membership attended and each individual heard a relatively small number of the papers given. Members leaving ASEE gatherings have been heard to remark, "That was really an interesting talk" or "There were really some good ideas in that paper but it was poorly organized" or "A good subject but a poor speaker" or "I personally like more facts and less opinions," etc., etc. Impressions of the speakers are often translated into opinions of the Society, and have much to do with its future. Those whose papers are selected for publication in the JOURNAL speak to much larger audiences and assume correspondingly greater responsibility.

Many excellent papers are selected for publication from those presented at meetings of the various divisions in connection with the annual meetings of the Society or papers presented at section or branch meetings. The divisions have been set up to draw together those with common interests, to enable them to discuss common problems, or to carry on important projects in their particular field of education. A member may well be interested in more than one of them. He is welcome to take part in as many of them as his interest dictates. Division, section and branch officers are constantly looking for speakers who can make worthwhile contributions to progress in engineering education. These speeches or papers are no less important than those presented before technical societies which are often the results of months or years of study and investigation.

The ASEE is the only society devoted exclusively to engineering teachers. It is our professional society. It does not concern itself with purely technical problems. To do so would be to infringe upon the functions of technical engineering societies. Many leaders in engineering are protesting against the multiplicity

of such organizations and find therein an obstacle to the effective organization of the engineering profession. We are indeed fortunate to have only one organization devoted to engineering education.

The ASEE owes its present position, its national and international prestige, its influence in the entire field of education to its prominent engineering educators, its competent committees and its active divisions, sections and branches. Through these agencies, individuals and groups of individuals have reported the results of years of study and research. They have exerted a profound influence upon the development of engineering education in these United States.

The future depends upon those who who will take it upon themselves to carry on the work so well done in the past.

"The heights by great men reached and kept
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night"

Many of us may not be able to reach the heights attained by past outstanding writers in the Society, but wise planning, early beginnings and constant effort may carry us further than we think.

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Where Do We Stand on Point Four?[1]

By the Honorable GEORGE V. ALLEN

Assistant Secretary of State for Public Affairs

President Truman, you will recall, launched the planning of a world technical cooperation program, on a cooperative basis, with his declaration of policy at his Inauguration last January 20.

He said that the United States, in cooperation with the UN, and with other governments, would attempt to pool the technical knowledge and skills of the more advanced countries to stimulate the progress of the underdeveloped countries.

There was obviously both selfishness and altruism in Mr. Truman's proposal. It was selfish because the United States does its greatest trade with the countries that are economically prosperous. It was selfish because an economy of private enterprise can remain most healthy in a world-wide expanding economy. It was selfish because the peace of the world and the security of the United States depends upon the well-being of the underdeveloped nations.

On the other hand, this plan was altruistic because the United States was not seeking any political favors. It was asking no privileges for American business greater than those accorded to businessmen from any other country. And the United States was willing to contribute more than its proportionate share in this program.

The President called his plan "bold and new." It is bold because for the first time a major nation has made it a national concern to facilitate the development of lesser developed countries, which contain well over half the population of the world, and because the plan looks beyond the immediate political alarms and crises to a long-range program, extending over many decades. This proposal is a demonstration of confidence in the possibility of achieving world peace.

The program is new in its world-wide scope. On a small scale, our government has had experience with this type of program in Latin America.

Now what has been happening on the plans for Point Four since last January 20?

The United Nations Organization has given active leadership. The Secretariats of the United Nations Specialized Agencies have had numerous meetings to discuss the work which their organizations might undertake in the fields of agriculture, education, health and general economic development. The Secretariats have now submitted their proposals to their various governing bodies. You may have seen a news story recently from New York, indicating that the total of these proposals would cost 84 million dollars for the first two years. Next month at Geneva, Switzerland, the Economic and Social Council will review these proposals. Thereafter the combined United Nations program will be examined by the United States and other members of the United Nations who are willing to contribute to the Point Four program. As you know, the Point Four program is a wholly voluntary con-

[1] Banquet address at the 57th Annual Meeting of the A.S.E.E., Troy, N. Y., June 23, 1949.

tribution, over and above our membership assessment in the United Nations.

Within the United States Government itself the Department of State has been given responsibility for drafting the necessary legislation and recommending a first year program. This work is now completed and the President will probably be sending to Congress this week a message requesting consideration of Point Four legislation at this Session.

It is not possible to discuss the contents of the first year's program, because each project will have to be negotiated with another government, and part of the expense will be borne by the other government.

However, I can assure you that engineering will play a prominent part in that program, and subject to approval by the United States Congress, and by other countries which may contribute to this cooperative venture, hundreds of American and other engineers will be going annually to assist the governments of underdeveloped areas of the world.

I do not mean to over-emphasize the role of government in this program, for it is likely that United States engineering firms and contractors will contribute a major share to the Point Four program.

Programs Now Under Way

I am unable to give you details of the proposed program, but let me review some of our recent experiences in working with other governments on engineering matters.

The government now has two programs of technical assistance in Latin America.

First, there is an Interdepartmental Committee on Scientific and Cultural Cooperation, which draws upon the technical skills and personnel of all the federal agencies to supply technical assistance to other governments. I am Chairman of that Committee, which has about 180 technicians working in Latin America today.

Second, there is a government corporation, the Institute of Inter-American Affairs, which is conducting programs for the improvement of the basic economy of Latin America. It works primarily in the fields of food supply, health and education. I sit on the Board of Directors of that corporation.

These two programs utilize engineering skills of many sorts in assisting other governments. Here are some examples:

1. *Mining.* If you go to Mexico City today, you will find in the laboratories of the Mexican Government two mining engineers supplied by the United States Bureau of Mines. These are shirt-sleeves men who are helping the Mexicans work out processes for extracting or reducing ores, so as to make mining less expensive. The United States supplied these men primarily because of our interest in lead, zinc, and other strategic minerals. However, they are available to work on any mining or metallurgical processes requested by the Mexican Government.

Since 1942, the United States has sent to Brazil a number of geologists to assist that government in locating and mapping its strategic minerals. These American geologists and their Brazilian colleagues have uncovered the largest deposits of manganese in the Western Hemisphere. The United States, since its earliest development of iron and steel, has been forced to import manganese from the other side of the Atlantic and the Pacific. Now, for the first time, we may become self-sufficient within this hemisphere. United States Steel has entered into a contract with the Brazilian Government for development of one of these manganese deposits.

2. *Irrigation.* In Haiti, an engineering field party of the Institute of Inter-American Affairs has just completed a small concrete aqueduct carrying water out of the mountains into the arid coastal plain about twenty-five miles behind the capital of Port-au-Prince. This aqueduct is irrigating approximately 1500 acres of land that have been largely abandoned since French colonial days over a hundred years ago, and the irri-

gated area is now being expanded. Haiti, as you may know, has a severe food shortage.

3. *Drainage for Malaria Control.* Engineers of the Institute of Inter-American Affairs were asked to tackle the malaria problem in the Santa River Valley in Peru where twenty-five per cent of the population were infected. The mosquitoes were breeding in marshes along the river. In one year the Institute engineers drained the area surrounding the mouth of the river, and the incidence of malaria dropped from twenty-five per cent to two per cent. The cost of this project was supplied largely by the Peruvian Government, and the labor was Peruvian. The United States supplied the technical knowledge.

4. *Aviation.* The Civil Aeronautics Administration has field parties in five Latin American countries today, advising other governments on the location and construction of their airfields, and the maintenance of their airways communications. Many of the United States personnel are engineers.

5. *Brazilian Air Mission.* In Brazil the United States has facilitated an entirely different kind of aviation mission. The Brazilian Government itself has recruited twenty of the outstanding aviation technicians of the United States, employed directly by the Brazilian Government to develop a national aviation program. The staff is headed by Dr. C. I. Stanton, former deputy administrator of the U. S. Civil Aeronautics Administration, and Professor Richard H. Smith, former dean of Aeronautical Engineering at M. I. T. These men have organized a complete engineering school for the Brazilian Government.

6. *Mechanical Engineers.* The Department of Agriculture has sent to Cuba several mechanical engineers who are helping to develop the necessary machinery for extracting fiber from the kenaf plant. Kenaf is an agricultural product developed by United States and Cuban scientists to replace jute. The agricultural phase of the work has been completed, but the machinery for processing the fiber is not yet satisfactory. When this project is completed, the United States will no longer be dependent entirely on the Far East for this important type of fiber.

7. *Water Supply Engineers in the Amazon.* The Institute of Inter-American Affairs engineers have supervised the construction of about twenty municipal water supply plants in Brazilian towns along the Amazon. The Amazon Valley was completely lacking in pure water systems, and water-borne parasites had become the principal national health problem. I recently heard an interesting anecdote about the first of these water systems in the Amazon, which was constructed in 1943. It was built in a town of 2500 people, which served as a county capital. The engineers, in order to allow for population expansion, built the system to supply 4000 people. Within two years after the water system was constructed, people had moved from miles around into this town, and its population had grown to 6000 people—fifty per cent greater than the water supply capacity. The plant had since been enlarged. Moreover, this town had been located for centuries on the bank of the Amazon, because everyone had to carry water in buckets from the river bank. Within one year after the water system was constructed, the population began moving inland from the river and the center of town now is almost two miles from the river, on higher and more healthful ground. That is what one American engineer can contribute to one foreign community.

8. *Training Engineers in the United States.* Many of our federal agencies are conducting classes and individual training courses for technicians from Latin America. More than 2000 technicians and scientists have been brought to the United States under this program during the past ten years. Approximately 400 of these were in various fields of engineering. Right now in Washington there are training courses going on

for Latin American engineers in the Public Roads Administration, the Civil Aeronautics Administration, the Bureau of Reclamation, the National Bureau of Standards, the Coast and Geodetic Survey, and the Public Health Service. This last agency is training sanitary engineers.

9. *London Science Staff.* An entirely different kind of engineering activity is represented by the Science Staff in the United States Embassy at London.

The Department of State has maintained a Science Staff in the London Embassy for almost two years. This staff both acquires and gives information on a scientific and technical nature.

Engineering Participation

Last year, from April 1948 to April 1949, an engineer was the Chief Scientific Officer—Dean W. R. Woolrich, Dean of the College of Engineering, University of Texas. His contribution to the work of the Staff was considerable, and is illustrative of the kind of assistance engineers will be giving to the Point Four program, as well as other U. S. foreign programs. He made a study of government sponsored research in the Department of Scientific and Industrial Research in Great Britain. He surveyed and appraised the whole system of engineering education, government and private, talking with officials in engineering schools and assessing the kinds of courses, methods of teaching, requirements for degrees, selection of students, and organization and management of engineering colleges. While in London, Dean Woolrich was a member of the U. S. Educational Commission in the UK administering the Fulbright program in Great Britain.

Dean Woolrich also worked on a plan to promote Western European interchange of unclassified industrial and agricultural technology now in possession of the governments participating in ERP. He cooperated with ECA and OEEC and with British and French government officials in developing the plan which has been accepted by the OEEC. Arrangements are now underway to put the plan into effect. Exchange arrangements are to be carried out by the countries among themselves. If successful, the project is likely to aid significantly in European economic recovery, and to place the cooperating countries in a much stronger position to participate in the Point Four program than they otherwise would be.

The best example I can recall of how the government and private enterprise work together in this field of technical cooperation is a story that came out of Afghanistan. In 1935, the Afghanistan Government sent to the United States a student of engineering. After he had graduated from an American engineering school, the Bureau of Reclamation took him into its laboratories at Denver for nine months of training. Shortly after this student returned to Afghanistan, he was appointed Minister of Public Works. When consideration arose in 1942 for the construction of a major dam in Afghanistan, this former student asked the United States Government if it could send a survey engineer. The State Department arranged for a trip by Mr. Jack Savage of the Bureau of Reclamation, whom many of you know as the designer of Boulder Dam. Jack Savage spent only a month in Afghanistan, advising on the feasibility of the project. The Afghanistan Government then issued a series of contracts to United States engineering and construction firms, now aggregating many millions of dollars.

Here in one sequence you can see the relationship of our program for foreign students, our training of foreign technicians in the United States Government agencies, our sending of technical advisers to other governments, and the role played by private American companies.

As soon as these professional schools are established, it is found that the scientific training and particularly the laboratory work in the high schools is inadequate, and it is necessary to revise the high school curriculum.

In many underdeveloped countries we find that education has been restricted to the wealthy families who have a social repugnance for hand labor. They lack what Harold Lasswell calls "the dignity of overalls."

International Exchange of Students

One of the methods which the United States has attempted to use in overcoming this attitude is to recommend handicrafts and shop work in the primary schools of a country. We have tried to break down the social attitude towards manual labor at the youngest possible age.

These educational problems are fundamental in any improvement to engineering services in most backward countries.

This year the United States has had over 25,000 foreign students enrolled in its universities. Approximately 5100 of these students were studying engineering. That is over twenty per cent. Nearly all of these students have been assisted at one time or another by our cultural officers in the American missions abroad, or by our reception centers in the United States for assisting foreign visitors. The State Department is doing its best, within the limits of our university capacity, to stimulate both the quantity and quality of the foreign students. The most important contribution to this program, however, has been the excellent fellowship program and counciling services of the various universities, including our engineering schools.

I believe we have been more successful in aiding foreign students to come to the United States than we have been in supplying visiting professors to institutions abroad. Under the Point Four program there will undoubtedly be a greater demand than at present for the sending of United States visiting professors of engineering to other countries.

And this brings me to a subject of particular interest to members of your organization.

I believe that the Point Four program will put a strain upon the available pool of skilled personnel in this country, including the engineering profession. The government will be looking to its own staff, to private engineering companies and to universities to determine what outstanding engineers are available for foreign assignment, and those who can be spared will be the first assigned. But I foresee in the second and third and ensuing years a demand for personnel which will compel the United States to turn to its young college graduates to undertake assignments abroad. Many of our technicians in Latin America today are under thirty years of age. I believe this is true of a majority of our sanitary engineers.

This is a problem which should be of concern to all of our professional schools. It means that some of our engineering students, to be properly prepared for their work, should have foreign languages and some "area studies." It means that the counseling services of our universities must become more familiar with the overseas opportunities for college gradates.

Such foreign assignments will be an all-around benefit to the United States and to the individual. The individual will be given experience far beyond his years, and beyond any opportunities he would have in the United States to exercise such broad authority at so young a period in his life. This in turn enriches the pool of trained man-power which the United States possesses, and gives our nation a richer experience in world affairs, which will enable us better to fill our new role in world leadership.

I have heard it said that engineers contributed more to the winning of the war than any other profession.

I foresee that the role of engineers in the program for peace, as laid down by President Truman, will be equally important.

Planned Individualism in Engineering Education*

By LIVINGSTON W. HOUSTON

President of Rensselaer Polytechnic Institute

On behalf of the faculty, my colleagues in the administration and the members of the Board of Trustees, as well as personally, I am happy to welcome you to Rensselaer Polytechnic Institute. I hope that your visit will be both pleasant and profitable.

Under any circumstances the annual meeting of the American Society for Engineering Education is a significant event. In the environment in which this gathering is being held it is especially significant. Today we meet not only to review the achievements of the year but also to commemorate a century and a quarter of continued progress in engineering education. In 1824 this institution opened its doors on the banks of the Hudson not far from the building in which we are gathered this morning. Those of you who represent the colleges of engineering throughout the United States and Canada will therefore find this pilgrimage of more than ordinary interest. Those of you who represent the industries of America will, I trust, find it no less interesting.

I am particularly happy that the American Society for Engineering Education has chosen to hold its annual meeting this year in Troy and to join with us in the celebration of 125 years of uninterrupted service. Although we at Rensselaer Polytechnic Institute take a modest pride in its history, engineering education has always been a cooperative undertaking; and your own institutions share with us the traditions which we cherish.

We are, therefore, proud that one of our graduates, DeVolson Wood, of the Class of 1857, was the first president of our first cooperative organization, the Society for the Promotion of Engineering Education, parent organization of the A.S.E.E. We are likewise proud that another man of Rensselaer, Benjamin Franklin Greene, was the first in America to analyze the problems of engineering education and to foster a forward looking program on the basis of his analysis. To quote the Wickenden report, Greene developed "an educational discipline complete in itself, not narrowly utilitarian but adapted to the complete realization of true educational culture."

Greene was a practical man. He went to Europe first and studied the systems of engineering education there. Then on the basis of what he had observed, he developed his own program here, a program which has given American engineering education its distinctive form and character. In its essentials this program is still sound today. Since Greene's day all colleges of engineering have contributed in some way to the development of engineering education. The American Society for Engineering Education stands, therefore, as a symbol of a great cooperative venture in which we are all pioneers.

Planned Coordination

In the constitution of our society one of the purposes is stated as "the coordination of institutional aims and programs both among the schools and colleges and in their joint relations with professional, educational and public

* Presented at the General Session of the A.S.E.E. Annual Meeting, Troy, N. Y., June 21, 1949.

bodies." To me the important words here are "coordination" and "joint." They suggest one of the things on which we must concentrate in the years ahead under the guidance of the A.S.E.E. even more than we do now. We have reached a point where such joint planning becomes essential. This is particularly true of our graduate and research programs. Our job has been vastly complicated by the many new developments in science and engineering. There is a great deal to be done and there are enough of us to do it, but I submit that we are going to have a steadily increasing degree of coordination between our programs if we are to function at peak efficiency. I do not mean to imply a program of planned economy.

Perhaps I can give this idea better focus if I give it a name. Let's call it "planned individualism"—among our schools; or if you like, cooperative competition.

We all enjoy competition. It is one of the bases of our American culture. You might almost say it is native to our soil. The results of it are what still set us apart from other nations. It has made us great, wealthy and powerful in industrial might. It has brought us to world leadership. It has given us tremendous responsibilities. But the blade of competition can cut two ways. One recalls the phrase, "cut throat" competition. That's out of favor now, but when our fathers were growing up, young America, bursting at the seams, looked with awe and with some admiration at men whose business practices would not pass muster today.

So we have learned that certain kinds of competition can get us into trouble. Today we watch our competitive practices, and when they prove unfair, we rule them out.

We have learned that in times of national crisis competition would work against the best interests of our country, and then we have turned to such forms of planning as price control, for example, and the pooling of our industrial know-how.

Competition Among Educational Institutions

American educational institutions delight in competition. We compete for students, for faculty, for money, for public favor, for industrial grants, for the support of philanthropic foundations, and we compete on the playing fields. We are competing for fame, and sometimes the type of fame has a tendency toward the superficial. It comes to mean anything that has a superlative "st" on the end of it.

For example, School "X" allows the world to find out that it has the biggest cyclotron; School "Y," that it has the longest wind tunnel, another one has the best towing tank, another the most powerful telescope, another the largest enrollment, another the biggest graduate school, another the prettiest co-ed, and I should certainly add here, still another the best lacrosse team.

We hire specialists in public relations to make sure that our alumni and the rest of the world know how many "st's" we can claim.

All these things I have been mentioning are part of our competitive system. Most of it is healthy, but some of it can be harmful. Part of it is superficial, and that doesn't matter very much, but some of it is basic, and that does matter.

Now I would like to recall what I suggested a few moments ago—what I called "planned individualism," or, if you prefer, cooperative competition. With a deep bow in all directions I would like to submit that no one of us is really *the* engineering school of America and in so far as we consciously try to earn the reputation of being that school, we run the danger of spreading ourselves too thin. There is manifestly far more for us to do than any one of us can accomplish alone. No one engineering school can be all things to all men. There can never be such an engineering school. Every school has some significant con-

tribution to make. The more we learn in our respective fields of concentration the more apparent this becomes. Attempts to satisfy all our potential customers, to meet the demands of every type of graduate student who comes to our doors will leave us in the somewhat unstable position of Stephen Leacock's hero, Guido the Gimlet of Ghent. As you recall, at one point Guido "leaped on his horse and rode off in all directions at once."

It is a commonplace to say that science and engineering become more and more a matter of team work. Within our respective graduate schools at this moment we each undoubtedly have teams made up, for instance, of an electrical engineer, a metallurgist, a biochemist, and an aeronautical engineer, working on a common problem which none of them could solve alone. Would it not be possible to develop an even greater measure of team work between the schools themselves. Steps toward this end have been made through the A.S.E.E. I am raising the question of whether it is not time to coordinate our program even further—in cooperative competition.

Obviously, what I am recommending applies mostly to graduate schools and research programs. It is in them that we run the danger of needlessly duplicating each other's efforts, of wasting time and money and personnel.

Please don't get the idea that I am advocating regimentation of curricula to the point where each school is arbitrarily allotted its particular fields of concentration. Such a concept is abhorrent to us all. I am simply suggesting that we could work out a voluntary program of planned individualism—and I stress the work "voluntary"—which could insure that we use our facilities, and our faculties and our funds to best advantage.

Industry-College Cooperation

I believe a further measure of cooperation is possible among us, particularly as it pertains to the support that American education must have from American industry. Some progress has already been made under the auspices of the A.S.E.E., as well as by individual colleges. I believe that more is possible and vital. I believe that American industry, if once properly educated, will come to recognize the extent of its responsibility to our scientific and engineering colleges, and will then act favorably on that recognition. It has not done so to date. That it hasn't is *our* fault. We have taken our story as individuals to individual companies. The job ahead of us is the education of all industry. This education of industry should be accomplished by a joint effort on our part and not piecemeal by each of us as individuals as we seek our special subsidies for our own projects. I believe that industry will welcome a comprehensive presentation of the matter which reflects the problems common to us all. I believe that we could then work out with industry a voluntary plan under which we would have a more equable and particularly a more efficient use of industry's support, and I believe that as a result of this cooperation the support would be vastly greater.

You have been given a little brochure with a red border at the top called "American Industry and the Colleges of Engineering." This is a survey made by Rensselaer, and the fact that each of you has a copy should indicate that it was made for the benefit of all. I have no doubt others of you may have made the same sort of survey in the past—or were perhaps contemplating something like it for the future. I hope it will benefit you as we hope it will benefit us. In any event, here it is for such use as we care to make of it. It doesn't give all the answers and it can't promise 100% accuracy. No questionnaire can fail to reflect the type of answer sought, as many of our eminent pollsters were quite ready to admit on the morning of last November 3rd.

Be that as it may, this industrial survey is very encouraging to me. The questionnaire was sent to the presidents of our great industrial firms and for the

most part it was the presidents who answered it, usually in their own handwriting. In replying to one of the questions, two-thirds of the more than 550 respondents stated that they believed business and industry should help the schools of science and engineering to a greater extent than they do now.

I construe this as a downright invitation. I believe it is a project which fits admirably into the program of our society. If we can educate American industry as well as we educate the engineers who are its life-blood, neither we nor industry need have any fears for the future. A whole industry has frequently banded together to tell its story to the general public. Usually when it has acted together in this manner, the results sought for were achieved.

With the ever mounting cost of laboratory equipment and with the growing complexity of our research programs, engineering education needs a solid block of financial support. Many of us believe that if this support were forthcoming from the National Government, serious restrictions on our institutional freedom would result. I believe that we can obtain that solid financial support which we need without large amounts of government aid and a continuing drain on the Federal Treasury.

Legislative Requirements

Congress should be persuaded to liberalize our tax procedure because many people with medium to large incomes just cannot afford to continue the generous support of education practiced a few years ago. Let us cooperate to help bring back this private form of educational support.

We must further, as a group, tell industry of our situation, our aims and our needs. And then we as individuals must seek out those industries which we can serve and which can best take advantage of working with us.

I congratulate this Society for the choice of the theme of this meeting—Partnership with Industry. I am certain that through the full realization of that theme we can achieve an educational program which will usher in an age of Health and Abundance for all peoples.

We are indeed honored that you are here to help commemorate the 125th anniversary of the founding of Rensselaer Polytechnic Institute.

Again, may I tell you how glad we are to have you with us at this time. This is your convention—we want it to be both pleasant and profitable—and we will try our very best to make it so.

E.C.R.C. Review of Current Research Available

A compilation of the titles of all currently-active research projects in engineering at the 82 institutions which are members of the Engineering College Research Council has been announced by the Council. The volume, published under the title *Review of Current Research and Directory of Member Institutions*, contains nearly 200 pages of data on research projects and policies. More than 4000 project titles are listed, and all are covered in an index of research project subjects.

Copies of the *Review*, which is compiled biennially by the Council, have been supplied to the libraries of all institutions which hold membership in the Engineering College Research Council. Members of the Society may obtain personal copies for $1.25 each, approximately cost; the book is regularly available to non-members for $1.75. Orders should be addressed to Mr. John P. Weber, Assistant Secretary of the Research Council, at the College of Engineering, State University of Iowa, Iowa City, Iowa.

The Financial Dilemma Facing the Colleges*

By FRANK C. HOCKEMA

Vice President and Executive Dean, Purdue University

Equality of educational opportunity has always been one of the fundamental ideals of American democracy. Starting with the constitution of the United States of America and the Bill of Rights as a foundation, there has been steady progress toward making this ideal a reality. During the past half century the enrollment in colleges has increased tenfold from 250,000 in 1900 to 2,400,000 in 1949. This increase is evidence of our belief that education plays an important role in the progress of American democracy in war and in peace. The validity of this belief in the value of education is supported by the results of a survey made recently by Dr. Harold F. Clark of Columbia University, which shows that there is a close relationship between the economic and social well-being and the educational level of a people.

In the broad sense, education includes all experience, all learning, all growth, and all self-development. In itself it is neither good nor bad; it can lead an individual upward and forward, or downward and backward. The danger is not that we may have too much education, but that we may obtain the wrong kind. To provide the right kind and the right amount of education for each citizen is, therefore, vitally important. There is no saturation point in *wise* education. Education must lead the way if we believe in that old axiom, "What we want in the nation, we must first put in our schools."

Mr. J. Edgar Hoover, Director of the Federal Bureau of Investigation, estimates the cost of crime at seventeen billion dollars annually. (The human suffering caused by crime cannot, of course, be measured in dollars and cents.) Crimes are committed by those who have become anti-social and destructive as the result of the wrong kind of education received in the homes, the churches, the schools, and the workshops of the nation, and from the movies, the press, the radio and television. Would it not be wise to spend for the right kind of education at least a portion of the seventeen billion dollars which is now lost annually because of crime? How much, in terms of dollars and cents alone, would it be worth to the nation, the state, and the community, as well as to industry and business, if each individual were taught to be honest, reliable, ethical, loyal, well-balanced mentally, socially, spiritually, and physically, willing to work hard and enjoy it, well equipped for his work, and well trained as a self-sustaining and contributing member of a free and changing society?

Quality Education is Costly

We need more than "quantity" education; we need "quality" education as well. The survival and progress of our nation depend on the quality of the educational system. It is bound to take a large amount of money to finance quality education, but we should always remember that education is the best investment we

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Grateful acknowledgment is made to the members of the A.S.E.E. Committee on Relations with Industry and to approximately two hundred industrialists and businessmen for their helpful suggestions.

can make if we wish to offer a greater degree of equality of opportunity for the youth of each succeeding generation.

One of the important functions of modern education is to assist the people of the country to use wisely the resources and opportunities at their disposal. Throughout the years the objectives of quality education have become broader and broader. Little by little, step by step, the complexities of modern life have forced an ever-widening field of activity upon the schools. During the war and since the war, the institutions of higher learning have played an important part in the tremendous task of educating the youth of this nation for good citizenship, with all its implications. The financing of this ever-expanding educational program has been a problem of increasing consequence.

The beneficiaries of the right kind and the right amount of education are not only the individuals who receive it but also the nation, the state, the community, and every member of the community; and, specifically, every employer. The beneficiaries of quality education should be willing to assume their share of responsibility for its moral and financial support.

The unprecedented demand for higher education since the war finds most of the eighteen hundred colleges and universities in the United States understaffed, underhoused, underequipped and underfinanced. An estimated 2,400,000 students registered for the scholastic year 1948–1949 are accommodated in an educational plant designed to serve a maximum of approximately 1,600,000. The United States Office of Education estimates that attendance by 1950 will approach 3,000,000 students.

Post-war enrollments have been inflated, partly by the return of veterans who had deferred their schooling, and partly by the encouragement given to veterans under the G. I. Bill to attend college. While some temporary leveling off in enrollments is looked for in the immediate future, other forces than the G. I. Bill are expected to keep college attendance at a high level. Among these forces are scholarships, fellowships, and ever-growing interests in higher education.

Causes of Financial Dilemma

Permit me to list some of the reasons for the financial dilemma now facing the colleges and universities:

I. *Enrollments have increased approximately 100%*

The present enrollments are approximately twice those of pre-war years. Teaching staffs as well as the laboratory and physical plant facilities are inadequate to do justice to this great increase in students.

A. The colleges must increase their staffs

Because of shortage of funds and because of lack of trained teachers, it has not been possible to add enough staff members to give maximum service to the students. The teaching staff has been and is underpaid and overworked. It must be realized that teaching is largely an art and as such must be individualized by insistance on small classes and teaching loads sufficiently low to permit the teacher to know and understand his students.

B. They must increase their library and laboratory facilities
Libraries should be adequate to accommodate the increase in enrollment in both the undergraduate and graduate programs, and the increase in faculty.

Although laboratories and classrooms are used in many institutions from early in the morning until late at night, additional laboratory facilities are needed.

C. They must increase other physical plant facilities

II. *Current economic conditions have created urgent problems*

The devaluation of the dollar has affected salaries and the prices of labor and materials, thus adding to the financial problems.

A. The colleges should increase the salaries of staff members

The teachers have been loyal. This loyalty should be rewarded as soon as possible by reasonable increases in salaries and a decrease in teaching load. The need for increase in salaries is aggravated by two important factors:

1. Living costs and taxes have increased

   The members of university staffs were already underpaid. Salaries must be raised to meet the increase in living costs and taxes.

2. Competition to obtain and keep competent staff members is keen

   Colleges and universities, industries, and businesses are all competing.

B. Grants, gifts, and bequests have decreased in number and amount

As living costs and taxes increase, grants, gifts, and bequests, especially from individuals, have decreased in number and amount.

C. Income from endowment funds has decreased

The interest rate on securities reached an all-time low during the war years, and has increased but slightly since the war.

D. Increased cost of labor and material hampers both new construction and maintenance.

Present building costs are about three times those of prewar costs for the same space. Because of the increase in the cost of labor and material, the need for additional new buildings can be met only by a large increase in funds for new construction.

In order to keep the physical plant in a good state of repair, constant work is necessary; and maintenance costs have increased at least 100%.

E. The costs of books, laboratory supplies, and other supplies have increased

III. *Post-war adjustment has created further problems*

A. Maintenance of physical plant had to be deferred during the war years

Because of the shortage of labor and materials, much of the maintenance of physical plant facilities was deferred. This accumulation of maintenance projects has now reached an all-time high.

B. New construction was postponed during the war

Because of the shortage of labor, materials, and funds, new construction during the war was reduced to a minimum.

IV. *Educational services must be expanded to meet the needs of the world today*

A. Research activities must increase

If research is all-important in time of war, it is equally important in time of peace. If this nation is to hold its place in the sun, the colleges must carry on more and more pure and applied research. Research laboratories, special

equipment, and research specialists are necessary.

B. The graduate program must be expanded

As our economy becomes more and more complex, we need increasing numbers of highly trained specialists educated and developed in the graduate schools. An adequate graduate program is costly.

C. An adequate counseling program is necessary

If education is to provide the right kind and the right amount of education for each individual, it is absolutely necessary to have an adequate counseling and vocational guidance program in higher education as well as in our secondary and even elementary schools.

D. Better public relations with business, industrial, and labor organizations must be maintained

In order that the education provided for the students may be practical as well as theoretical, the colleges and universities will have to spend more money in keeping the members of the teaching staff in close touch with off-campus organizations. This involves funds for staff travel and frequent leaves on pay for visits to other institutions, advanced study, and work in industry and business. Staff members should be encouraged to work in industrial and/or business organizations for a semester or two every three or four years.

Sources of Funds

If the beneficiaries of the right kind and the right amount of education are expecting the colleges to do a good job for them, adequate funds must be provided from one or more of the following sources:

1. *Tuition and fees.* The amount of the tuition and fees varies greatly among the colleges. The tuition and fees may have to be increased in some colleges and decreased in others. In most instances the individual student bears this cost. Yet the student's tuition and fees rarely pay for as much as half the cost of his education.

2. *Endowments.* Drives are being planned, especially by the private colleges, to increase the endowment funds. The colleges will have to depend a great deal on an increase of donors of small gifts, and on the possibility of an increase in interest rates.

3. *Community aid.* Since the community is a top beneficiary of the quality education of its members, it should assume its due share of moral and financial support of the local college. Too many communities that are able to support their own colleges often ask for federal aid, thereby asking other communities to help carry their responsibilities.

4. *State aid.* Since state universities rarely have endowment funds, they must depend upon state appropriation for the major part of their support. Yet it is difficult to obtain adequate appropriations for the effective operation of the state universities from state appropriations alone.

5. *Federal aid.* At present federal aid is provided for the veterans who qualify under the G. I. Bill of Rights and for certain nation-wide areas of training and research that are of special importance to the country. The Federal Government pays for the direct cost of education of those veterans who qualify under Public Law 346 and Public Law 16; the "direct cost" is approximately sixty per cent of the total cost. The decrease in G. I. enrollment will reduce the income from Federal funds to such an extent that the colleges will have to look elsewhere for additional funds. Several

bills are now before Congress providing for a great expansion of Federal aid, which some individuals think might be the beginning of Federal control of our educational system.

The land-grant colleges and universities have been the beneficiaries of Federal aid for higher education for over seventy-five years, and at no time has this involved dictation on the part of the Federal Government. During the 1930's many colleges and universities were able to construct new buildings because of the financial aid from the Public Works Administration. These grants did not imply Federal control. Federal aid for specific nation-wide programs of training and research has been made available during the past several years to certain colleges and universities, with little or no Federal control. Federal aid to education is now requested by certain persons and groups because of: (1) the vanishing American dream of proper schooling for all who are qualified; (2) the inequalities of the income, or wealth, of various sections of the nation; and (3) the inadequacy of funds for education available from other sources.

Other persons and groups are opposed to increased Federal support of higher education because they fear the possibility of Federal control of education. The statement which follows is from a speech that General Dwight D. Eisenhower made in Albany, New York, on October 15, 1948:

> Because I believe that the Federal Government has no right to tax money out of our pockets and give it back to us without some form of supervision, therefore, I say that they cannot give federal money for the support of higher education. When federal money comes into that field, we are entering a dangerous situation.

6. *Aid from industry and business.* Many industries and businesses have provided some financial aid to colleges. Many would do much more if it were possible under state and national laws. Industries and businesses have made funds available: (1) to competent and needy students in the form of scholarships and fellowships; and (2) to the qualified colleges for educational and research projects.

7. *Aid from other sources.* Other organizations, such as trade associations, foundations, institutes, and labor groups, have contributed to education. These organizations should be encouraged to continue to do their part in the over-all program of quality education.

Cooperation of Industry and Business with Education

Because of the extensiveness of the topic, "The Financial Dilemma Facing the Colleges," the discussion must be limited to one phase of the problem. I should like to consider with you one source of the colleges' financial dilemma which I think is especially important: *the stake that industry and business have in education.*

Colleges and universities, both private and public, which have rendered recognized service to industry and business have enjoyed a cordial relationship with a large number of industrial and business organizations throughout the years. Educational institutions report very favorably on cooperation with industry and business and look upon it as a two-way process. They are prone, of course, to stress the services which they are prepared to render industry and business. But corporations which have worked with colleges and universities are also favorably disposed toward cooperation.

Most of the industrialists and businessmen are more or less aware of the financial problems confronting higher education, and many of them are asking questions such as the following:

1. Which colleges deserve financial assistance?
2. Can recognized accrediting agencies help to classify colleges?
3. Should preference be given to local institutions?
4. How much money is needed?

5. From which sources should funds be provided?
6. How much should each industrial and business organization contribute to supplement the income from other sources?
7. In what form or forms would financial aid be most effective?
8. Should there be restrictions on the funds donated?
9. Will the obligation be a continuing one?
10. How are the funds to be administered?

The several institutions of higher learning, both private and public, had better be prepared to be examined by the practical and realistic industrialists and businessmen. Each college should put its house in order and be able to give a constructive answer to the following questions:

1. How great is the future demand for the kind of persons being educated by this and similar colleges? Are the undergraduate curricula overspecialized?
2. Does this college operate on sound financial and academic policies?
3. Does it make maximum use of classrooms, laboratories, and other facilities on the basis of space and time?
4. Does it provide each of its students with friendly and helpful service and an individualized and humanized educational program, gauged to his preparation, learning rate, aptitudes, interest, and capacity, so that he can make the progress of which he is capable under experienced and inspired leadership?
5. Does it improve and develop each student who is admitted regardless of whether he remains in the college one or two years on a terminal program or four years on a program leading toward a degree?
6. Is it vitalizing its students with a motivating, active interest in and concern for the meaning of American freedoms and the responsibilities of good citizenship?
7. In which specialized fields is it adequately equipped to carry on research?
8. Is it well organized and adequately supervised?
9. Does it have a high grade, active, growing, and adequate teaching faculty and scientific research staff?
10. Does it have exceptional staff members in the key positions?
11. If this college is overexpanded and/or overstaffed, how shall this situation be remedied?
12. Does this college have definitive plans which justify future expansion?
13. Does it enjoy the respect of industrialists and businessmen?

Attitude of Industrialists

If the colleges do their part well, then the further question is—What is the attitude of industrialists and businessmen toward colleges in need of financial support? Permit me to quote several distinguished men who have the reputation of understanding the problems confronting industry, business, and education.

Mr. Laird Bell, an attorney of national repute, said in a recent address:

> If education does its part well, industry in contributing to education benefits both itself and education. This is, I believe, amply demonstrated by the fact that some twenty concerns, headed, incidentally, by the oil companies, have subscribed $3,000,000.00 over a 5-year period for work in pure science in the Nuclear Institute of the University of Chicago. The National Industrial Conference Board has made a number of studies of corporate contributions. They found that 71 of the 100 largest manufacturing corporations gave over 16 million dollars to charity in 1947, while half of this went to community purposes and only a little over 2 millions went to education.[1]

[1] Bell, Laird (Chairman of the Board of Trustees, University of Chicago): "Co-

Mr. Frank W. Abrams, Chairman of the Board of Standard Oil of New Jersey, in a recent address acknowledged the debt that business and industry owe to education. He said in part:

If business and industry could not draw upon a large reservoir of educated manpower, they would be handicapped in every phase of their operations. American education does a job for business and industry. If our hope of an advancing American economy involves reducing costs, increasing individual productivity, and devising better ways of doing things, we must consider that we have a major interest in helping American educators in their work.[2]

It is my personal opinion that the peace, prosperity, and security of this nation may depend as much on the way we treat our teachers and our religious leaders as it does on any other single influence. We believe that the individual is important and should always come first. Colleges and universities are today more and more looking to business and industry for help—and I think they are right in doing so. More and more the corporate individual is being asked to assume some part of the responsibility that the private individual is not so well situated to carry with present taxes and surtaxes—and I think it is interesting and significant that corporation giving to various forms of philanthropy has increased tenfold in the past decade. I believe that the will to contribute exists very widely today in the field of business and industry, but I find that very few people (among them very few educators) are aware of the substantial obstacles to giving which the law puts in the path of the public spirited corporation management.[2]

Mr. John L. McCaffrey, President of International Harvester Company, declares that in education business has a "legitimate business interest at stake." In a recent address he said:

If we are to maintain and expand our educational system, we must do more than offer good wishes. We must give financial support to the limit of our abilities. We must give assistance by every other means possible.

Aside from our interest as individual citizens, we have a legitimate business interest at stake. Every businessman today needs to know enough about the society in which he lives and operates so that he can follow its changes intelligently, adjusting himself and his business to changing times, and making sure that his business serves its most useful purpose for society.[3]

Dr. Frank B. Jewett, President of the National Academy of Sciences, has said:

I urge that income tax credit under discussion be formulated in terms sufficiently broad to include private gifts to all agencies of higher learning, as well as to all lines of research and investigation carried on with them. This suggests as an initial goal a sum of 70 million dollars, which is less than 3% of the tax reduction now in contemplation for 1947–48. And when contributions from corporations are taken into account, the sum that is required from private givers becomes truly a very minor quantity in comparison with tax reduction. My proposal then is—that of the shortly-to-be-established tax reduction, Congress in effect channel approximately 2 to 3% to American scholarship, by the expedient of telling the taxpayer that he will get full tax credit (within limits to be set) for whatever contribution he makes to educational and scientific agencies. If he chooses not to make such a contribution, he may expect the tax collector to demand an equal sum of money.[4]

operative Planning for Education and Industry." Address delivered before the 1948 Texas Personnel Conference, November 5, 1948.

[2] Abrams, Frank W. (Chairman of the Board, Standard Oil Company of New Jersey): "How Can American Business Help American Education?" Address delivered before the Thirty-fifth Annual Meeting of the Association of American Colleges, January 11, 1949.

[3] McCaffrey, John L. (President of the International Harvester Company). Address delivered before the Convention of the American Bankers Association in Detroit, Michigan, September 29, 1948.

[4] Jewett, Frank B. (President, National Academy of Sciences): "The Case for Continued Private Support of Fundamental Science," March 11, 1947. Presented before the Committee on Interstate and Foreign Commerce, Washington, D. C.

The following resolution was adopted at the 1948 Congress of American Industry and the National Association of Manufactures:

> The 53rd Congress of American Industry emphasizes industry's interest in education and calls upon all employers to initiate and promote closer ties between industry and education in their own communities, to give active leadership and personal support to the maintenance of adequate educational facilities and the compensation of teachers on a basis which is consistent with their professional stature.[5]

Nature of Financial Aid

There seems to be rather general agreement among the industrialists and businessmen that they want to render moral and financial support to worthy institutions of higher learning. Such assistance would be extremely helpful to colleges and universities, both private and public, in supplemental support of their wide range of activities in education, research, and public service. Many of the industrialists and businessmen have asked for suggestions on ways in which corporations and businesses may help finance sound education. The following means of assistance to colleges are offered for favorable consideration:

I. *Fellowships and grants.*
   1. Funds for basic and applied research.
   2. Funds for research fellowships.
   3. Provision for research equipment and materials.
   4. Loans of equipment and scientific apparatus.

II. *Scholarships.*
   1. Undergraduate scholarships given as outright and unrestricted gifts.
   2. Scholarships:
      a. For employees.
      b. For children of employees.
      c. For individuals in the community.

III. *Loan funds.*
   1. To worthy and needy students.
   2. To worthy and needy faculty members.

IV. *Outright and unrestricted gifts.*

V. *Services to professors.*
   1. Employment of professors at salaries they receive plus an extra amount to take care of increased family expenses:
      a. During summer vacation.
      b. During leave of absence.
   2. Greater use of college professors as consultants.
   3. Teaching fellowships.
   4. Awards to professors to stimulate good teaching.
   5. Opportunities for professors to visit plants at company expense.
   6. Establishment of schools for professors within the plants, to teach teachers how business really runs on a free enterprise basis.

VI. *Services to students.*
   1. Employment of students during summer vacation.
   2. On-the-job training in connection with college work.
   3. Opportunities for student groups to visit plants.
   4. Special awards to students, particularly in activities which stimulate inventiveness and self-expression.

VII. *Services to prospective students.*
   1. Promotion of interest in education among qualified high school students by local industries and businesses.

VIII. *Machinery and equipment.*
   1. Donations of machinery and equipment for laboratory and classroom work.

[5] Resolution adopted at the 1948 Congress of American Industry, National Association of Manufacturers, The Waldorf-Astoria, New York City, December 1, 2 and 3, 1948.

2. Loans of machinery and equipment for laboratory and classroom work.
3. Discounts on machinery and equipment sold to colleges.

IX. *Teaching aids.*

1. Gifts and loans of educational films and exhibits.
2. Provision of material for textbooks.
3. Provision of pamphlets describing production techniques, product specifications, and personnel requirements.

X. *Company specialists.*

1. Loans of research specialists to universities and colleges for scientific lectures.
2. Loans of production specialists for lectures on manufacturing.
3. Loans of personnel specialists for lectures on industrial relations.
4. Loans of administrative specialists for lectures on company policy.

XI. *Extension service.*

1. Assistance in organizing extension classes.
2. Provision of facilities for extension laboratories and classrooms.
3. Cooperation in providing postgraduate programs for employed college graduates.

The right kind of colleges and universities, both private and public, which show leadership, imagination and initiative, will give the most efficient service to their students with whatever funds are available. The increasing waste of our intellectual resources can be avoided only through the use of additional funds. Funds from the communities, churches, states, individuals, unions, trade associations, institutes, foundations, and federal government support in emergency and for certain areas of training and research of a national scope, supplemented by whatever funds industry and business wish to invest in education, should make it possible to provide the right kind and the right amount of education to each citizen. We shall pay disastrous penalties if educational neglect is continued.

Colleges and universities welcome and appreciate a growing recognition on the part of industrialists and businessmen that a progressive educational system has been, and will always continue to be, vital to our American business and industry.

College Notes

The **Foundry Educational Foundation**, which conducts a college level educational program for the entire foundry industry in seven engineering schools, will expand its program to include five more colleges in 1950. During its first three-year cycle, the Foundation awarded 148 scholarships of one year each to 102 students, some of whom received more than one unit.

The Foundation's program is in effect at Massachusetts Institute of Technology, Cornell University, University of Wisconsin, Case Institute of Technology, University of Cincinnati, Northwestern University, and the University of Alabama. Next year it will include Ohio State University, Purdue University, Michigan State College, Pennsylvania State College, and the University of Missouri School of Mines and Metallurgy.

Paul R. Trumpler, of Olean, N. Y., has been appointed professor of mechanical engineering at **Illinois Institute of Technology**, Professor Frank D. Carvin, director of the department, announced today.

Engineering Mission to Latin America*

By S. S. STEINBERG

Dean, College of Engineering, University of Maryland

This paper is a sequel to the one entitled "Engineering Education in Latin America" (JOURNAL OF ENGINEERING EDUCATION, Vol. 37, No. 4, December, 1946). The first paper described the writer's observations on a tour during the summer and fall of 1945 through twelve of the republics of Latin America under the auspices of the U. S. Department of State. The present paper presents similar observations during the summer and fall of 1948 under the same auspices and covers the eight remaining countries south of our border. This engineering mission to Latin America was the first ever undertaken to determine by personal observation the status of engineering education, the engineering profession, and engineering projects, in all twenty other American republics. On both tours, the writer was privileged to serve as the official representative of the engineering schools as well as of the engineering societies of the United States to the corresponding groups in the Latin American countries.

* Paper presented at the 57th Annual Meeting of the American Society for Engineering Education, Troy, New York, June 20–24, 1949.

EDITOR'S NOTE: *This is the second paper by Dean Steinberg resulting from his mission as our Society's Ambassador of Good Will to the 20 other American republics. The success of his ambassadorship is indicated by the fact that during the course of his travels he was named an honorary professor of eight Latin American national universities and an honorary member of an equal number of engineering societies.*

Engineering Schools Visited

Following is a list of the engineering schools visited on the second tour presented in the order in which they were inspected. The accompanying map locates the schools geographically. Six of the countries are in the Caribbean area while the remaining two, Bolivia and Paraguay, are both land-locked in the very heart of South America.

Guatemala
University of San Carlos, Guatemala City

El Salvador
University of El Salvador, San Salvador

Honduras
Central University of Honduras, Tegucigalpa

Nicaragua
Central University of Nicaragua, Managua

Bolivia
University of San Andreas, La Paz
Technical University of Oruro, Oruro

Paraguay
National University of Paraguay, Asuncion

Dominican Republic
University of Santo Domingo, Ciudad Trujillo

Haiti
University of Haiti, Port-au-Prince

The eight countries visited on the second tour are, in general, the Latin American republics that are the least developed

economically and from the engineering point of view; they are, therefore, those that are in greatest need of the services that only the engineer can provide, namely, highway and railroad transportation, sanitary and health facilities, the development of agricultural and mineral resources, and, finally, industrialization. There is one engineering field in these regions in which progress has been rapid and phenomenal, namely, in air transportation. Aviation has opened up vast interior areas that previously were inaccessible on account of great physical barriers, and has served to put them in direct contact with the outside world. There are still many natives in interior fastnesses in the southern part of the

DATA ON ENGINEERING SCHOOLS VISITED IN 1948

Country	University and Engineering School	No. of Students			No. of Faculty	Courses Offered	Course in Yrs.	Yr. Present Engrg. School Founded or Reorganized	Remarks
		Male	Female	Total					
Guatemala	University of San Carlos Faculty of Engineering	298	13	311	24	C.E.	6	1922	Class hours: 7–9 A.M.; 5–7 P.M.
El Salvador	University of El Salvador Faculty of Engrg. and Arch.	148	2	150	22	C.E.	5	1927	Class hours: 8–12 M.; 2–5 P.M.
Honduras	Central University of Honduras Faculty of Phys. Sci. and Math.	79	3	82	18	C.E.	5	1904	Require additional year practice and thesis.
Nicaragua	Central University of Nicaragua Faculty of Engineering	49	1	50	22	C.E.	5	1941	Class hours: 6:30–8 A.M.; 12M–6 P.M.
Bolivia	University of San Andres Faculty of Exact Sciences	76	1	77	46	C.E. Ind. E.	7 7	1940 (C.E.) 1943 (Ind. E.)	Data given excludes Arch.
	Technical University of Oruro National School of Engineering	248	2	250	13	C.E. E. Mines	6 6	1905	Has full-time faculty
Paraguay	National University of Paraguay Faculty of Math. and Phys. Sci.	46	4	50	18	C.E.	6	1926	Class hours: 2–7 P.M.
Dominican Republic	University of Santo Domingo Faculty of Exact Sciences	290	10	300	20	C.E. Arch. E.	5 5	1914	University founded in 1538
Haiti	University of Haiti School of Engineering	62	0	62	27	C.E.	4	1947	School of Applied Sciences founded in 1902

hemisphere who have never seen a railroad train or an automobile but who feel perfectly at home at an airport.

The efficiency of air transportation in these countries made possible the wide area coverage by the writer in a comparatively short space of time. On his two trips, he travelled a distance of approximately 32,000 miles in a total period of six months, with sufficient time available to see and to observe in each country most of its activities related to engineering and engineering education.

Data on Engineering Schools

The accompanying tabulation gives certain data on each of the engineering schools visited by the writer in 1948. These include enrollment, faculty, courses and hours of instruction. It will be observed that the faculty members are practically all on a part-time basis and the hours of instruction are arranged to fit the climate and to suit the convenience of both faculty and students, all of whom are otherwise gainfully employed. The salaries paid the members of the engineering teaching staff are pitifully small. For a class taught three times a week, the monthly compensation is $40 in Guatemala, $50 in El Salvador, and only $20 in Honduras.

While individual variations exist in the engineering schools in the different countries, depending upon the length of the course and the special local requirements, the following is a typical curriculum of six years duration:

Course of Study leading to degree of Civil Engineer:

	Hours per Week
Pre-Engineering Course	
Trigonometry	6
Advanced Algebra	3
Mathematical Physics	6
General Chemistry	6
Descriptive Geometry	6
Geometric Drawing	3
Total	30
First Year	
Analytic Geometry	3
Infinitesimal Calculus I	3
Specialized Chemistry	6
Geology	6
Surveying	6
Topographical Drawing	3
Total	27
Second Year	
Technical Mechanics	6
Infinitesimal Calculus II	3
General Hydraulics	6
Advanced Surveying	6
Geodesy	6
Mechanical Drawing I	3
Total	30
Third Year	
Structures I	6
Electrotechnics	6
Building Materials	3
Civil Constructions I	6
Sanitary Engineering	6
Mechanical Drawing II	3
Total	30
Fourth Year	
Structures II	6
Mechanical Engineering	3
Electrical Engineering	3
Reinforced Concrete	6
Highways	6
Civil Constructions II	6
Total	30
Fifth Year	
Bridges	3
Estimates and Specifications	3
Aesthetics of Construction	3
Statistics	3
National Economics	3
Engineering Contracts	6
Total	21
Grand Total	168

Projects

A minimum of 6 months of practical work is required.

In addition to the curricula listed in the tabulation, most of the engineering schools offer a two-year course for Surveyors. This course usually comprises

the first two years of the regular Civil Engineering curriculum.

Economic Considerations

Although each of these countries maintains an engineering school, in many of them the facilities for engineering instruction are very meagre. In some cases, laboratories are non-existent. Some do not even possess the most elementary laboratory facilities in Chemistry, Physics, or other fundamental courses and yet engineering degrees are awarded annually. The instruction is wholly theoretical, is based largely on mathematical theory and, in general, is unrelated to practical engineering work. The reasons for the low status of the engineering schools in these countries is almost wholly economic. With some exceptions, the mass of the population is illiterate, under-paid, under-fed, and often indifferent as to its own status. Public works are meager, yet the need for them in almost every field of engineering is very great. Most of the countries abound in rich natural resources, largely untapped, but which, if developed, could provide profitable employment for the native population and bring great benefits to the country. The lack of engineering development in some of the countries is due to poverty, to political instability, to adverse topography, to climate, to lack of local incentive, to lack of security for investment of foreign capital, to the scarcity of engineers, and to failure to establish a policy regarding public improvements that are so greatly needed.

In most of these countries, the officials who have control of the universities and the engineering schools realize the need for improvement of their faculties and their facilities, but in most cases they are unable to do much about it because of local economic factors. Others have recognized the need for trained engineers and have undertaken projects to improve their physical facilities. Several countries have plans in various stages of completion, or have already built a "Ciudad Universitaria," or "University City," which corresponds to our campus.

Examples of Progress

The University of San Andres, in Bolivia, has followed the pattern of the University of Pittsburgh in erecting a handsome twelve-story building, the tallest in La Paz, the highest capital in the world. It is located in the Andes mountains at an altitude of more than 12,000 feet. The height of the University structure, which by law no other building in the city will be permitted to reach or to exceed, symbolizes the high place of education in the life of the Republic. The writer was interested to observe on his inspection of this building that six of the twelve stories are assigned to engineering and allied departments.

The University of Santo Domingo, in the Dominican Republic, has similarly made excellent progress. It has already erected six modernistic, spacious buildings on a beautiful site on the outskirts of Ciudad Trujillo, the capital. Thus far, no building has been erected for the Faculty of Exact Sciences (Engineering), which is temporarily housed in the unit belonging to the Faculty of Dentistry. The plans for an engineering building have been completed and it is hoped funds will soon be provided for its construction. The University of Santo Domingo is claimed to be the first institution of higher learning in the western hemisphere, having been authorized by Papal Bull on October 28, 1538, a century before the founding of Harvard University, the oldest in the United States. This University is located in a land that is the cradle of civilization in this hemisphere. It is on an island discovered by the Great Admiral, Christopher Columbus, and where, by his own request, his mortal remains are today.

With the two exceptions just noted, all the remaining engineering schools in this group are in great need of new buildings; but, what is more important, they are in greater need of laboratory equipment, as previously noted.

The Faculty of Engineering at the Technical University of Oruro in Bolivia is unique in several respects. It is located at an elevation of 13,500 feet. Of the nine engineering schools visited on the second tour, only this school has a full-time faculty, and they are justly proud of that fact. The only other engineering school in this category in Latin America is that at the Central University of Venezuela visited on the first trip. The members of the Oruro engineering faculty are prohibited by law from engaging in outside professional activity. While the Oruro school does not have the advantage of the large income from petroleum resources possessed by the engineering school in Venezuela, it does own a mine which produces principally silver and lead, the income from which goes to the engineering school and makes possible the full-time faculty.

Suggested Plan

In discussing with many of the leaders in these countries the great need for properly trained engineers, the writer has suggested the possibility of utilizing some of the military budgets and military schools for this purpose. The plan suggested was to arrange the training in the military schools so as to include engineering fundamentals in addition to military science. Then students qualified by mathematical and scientific ability could, upon graduation, as in the case of our own West Point, enter upon engineering public works, and thus furnish a supply of engineers so greatly needed. As in all countries these days, the military budget is the largest of all governmental expenditures. If some of these funds could be allocated and expended annually on a priority basis for laboratory equipment necessary for proper engineering instruction, great benefits could accrue to the entire country. Under this plan, military men could be of great service to their countries in time of peace and not be dependent wholly for utilization of their abilities in time of war. Several of the military leaders looked with favor upon this proposal, and it is possible that the plan may be tried soon in at least two of the republics.

The Engineering Profession

The engineering profession in these countries recognizes the deficiencies that exist in their engineering education and they are anxious to cooperate in every way that will further education and professional advancement. Each of the eight countries visited, except Nicaragua, maintains an active engineering society which is working closely with its faculty of engineering. Almost all the engineering teachers are practicing engineers and are members of these societies.

Following is a list, arranged alphabetically by country, of the engineering groups visited by the writer on his two tours. It was his pleasure to address and to be delightfully entertained by 24 principal engineering societies located in 19 countries:

Argentina
- Argentine Society of Engineers, Buenos Aires

Bolivia
- Society of Engineers of Bolivia, La Paz

Brazil
- Institute of Engineers of Sao Paulo
- Engineers Club of Rio de Janeiro
- Brazilian Engineering Federation, Rio de Janeiro
- Engineers Club of Pernambuco Recife
- South American Union of Engineering Societies, Rio de Janeiro (1948)

Chile
- Institute of Engineers of Chile, Santiago

Colombia
- Society of Engineers of Colombia, Bogota

Costa Rica
- Society of Engineers of the Republic, San Jose

Cuba
Cuban Society of Engineers, Havana

Dominican Republic
Dominican Society of Engineers and Architects, Ciudad Trujillo

Ecuador
Society of Engineers of Ecuador, Quito

El Salvador
Society of Engineers of El Salvador, San Salvador

Guatemala
Association of Engineers of Guatemala, Guatemala City

Haiti
Haitian Association of Engineers and Architects, Port-au-Prince

Honduras
Society of Engineers of Honduras, Tegucigalpa

Mexico
Association of Engineers and Arehitects of Mexico, Mexico City

Nicaragua
Has no organized engineering society

Panama
Society of Engineers of Panama, Panama City

Paraguay
Paraguayan Society of Engineers, Asuncion

Peru
Society of Engineers of Peru, Lima
Institute of Mining Engineers of Peru, Lima

Uruguay
Association of Engineers of Uruguay, Montevideo
South American Union of Engineering Societies, Montevideo (1945)

Venezuela
Society of Engineers of Venezuela, Caracas

Engineering Cooperation

The writer was greatly pleased to note on both tours the splendid contributions to the progress of the Latin American countries made by several of our own government agencies in the development of education, transportation, sanitation, and health. These engineering accomplishments have already served in each country as excellent object lessons of the contributions that the engineering profession can make to the health, the happiness and the economy of the nation. It was particularly gratifying to be told by native engineers, physicians, ministers of public works, and even by several presidents of the republics visited, how much they appreciate what has been accomplished through our cooperative efforts. Following is a brief summary of some of these outstanding projects inspected by the writer in his travels.

Inter-American Highway. This highway extends from Laredo, Texas, through Mexico and the six Central American republics to the Panama Canal, a distance of approximately 3300 miles. Work on the portion of this highway traversing Mexico is directed and financed entirely by the Mexican government. In the Central American republics, the United States government, through the Public Roads Administration, has been cooperating for several years with these countries in financing and building the highway. All construction work is performed by local labor, while the employees from the United States are small in number and fill engineering, administrative and accounting positions.

The status of the Inter-American Highway at the beginning of 1949 is that it is passable either on paved all weather, or on dry weather roads most of its length. This is true through all of Mexico, except for some 60 to 70 miles north and south of the Mexico-Guatemala border; through Nicaragua except for 33 miles; and for all of the remainder of the highway except for about 100 miles north and south of the Costa Rica-

Panama border. When the Inter-American highway is open for its entire length, the motorist will be able to traverse one of the most spectacular roads in the world. He will be able to travel from the steaming jungles of the tropics, across cool plateaus, and then climb to the top of a cold mountain range in Costa Rica which is crossed at an elevation of 11,000 feet.

Many advantages have accrued to the other American republics through United States participation in this work. The highway has provided transportation facilities where formerly none existed; has opened up new areas with untapped resources; has served to promote advancement of agriculture, industry, and commerce; has brought together the peoples of neighboring countries who before highway or air transportation was available, were neighbors in name only; and finally, has assisted in the development of a skilled highway organization in each of the countries with engineers, supervisors, and workmen obtaining experience in actual construction.

In addition to its cooperative activities in Central America, the Public Roads Administration has provided engineering advice and assistance on highway projects to the governments of Bolivia, Dominican Republic, Ecuador, Haiti, and Venezuela.

Institute of Inter-American Affairs. The health and sanitation program of this Institute started in 1942, and operates under cooperative agreement between the United States and most of the other American republics. It is designed to aid and improve the health and general welfare of the people of the western hemisphere. Agreements have been completed, or are now in operation, in all the countries to the south except Argentina and Cuba. These cooperative undertakings have illustrated the great benefits that can accrue to a country when the physician and the engineer pool their professional knowledge.

The projects include construction or improvement of medical and public health facilities, including hospitals and dental and other clinics; sanitation, including water supplies, sewerage systems, and community sanitation facilities; health centers and laboratories, including health education, immunization, malaria, hookworm, yaws, and rat control; and training of technicians in public health and sanitation activities, including physicians, nurses and sanitary engineers, who are trained in graduate schools in the United States or through courses conducted within the countries.

Each project is housed in an attractive, comfortable building designed to harmonize with the local architecture, and constructed of local materials. The costs are shared by both cooperating governments. After project facilities are constructed, their operation and maintenance becomes a function of the municipality.

The writer had the privilege on both tours of observing the construction and operation of many of the projects sponsored by the "Servicio," as it is familiarly known south of our border. Reviewing the second tour only, he inspected such widely diverse projects as the 1000-bed national hospital under construction in Guatemala City; the municipal slaughterhouse and the municipal public laundry in San Salvador, and the sewage treatment facilities at Santa Tecla, both in El Salvador; the water supply system and the tuberculosis hospital in Tegucigalpa, in Honduras; the new sanitary engineering laboratory at the University of San Andres, and a similar one at the Technical University in Oruro, both in Bolivia; the health centers and dispensaries in Asuncion, as well as the construction for the leper colony at Sapucay, both in Paraguay.

Due to these cooperative activities and the stimulus supplied by the Institute of Inter-American Affairs, practically all the engineering schools in the countries visited on the second tour are giving greater attention than heretofore to instruction in Sanitary Engineering. In some of the schools this specialty is being offered as an option in the final

year of the Civil Engineering curriculum.

Some of the other cooperative projects with agencies in the United States that have brought great benefits to the other republics include the Inter-American Geodetic Survey, in their extensive mapping projects; the United States Coast and Geodetic Survey, in training personnel; the advanced training program for highway engineers sponsored by the American Road Builders' Association; and many others.

Pan American Engineering Congress

As a direct result of the personal contacts established with the engineering schools and engineering societies in the other American republics, the First Pan American Engineering Congress has been called to meet in Rio de Janeiro, Brazil, in July, 1949. The Congress is being sponsored by the South American Union of Engineering Societies, and in this country, by the Engineers Joint Council, composed of the representatives of our major national engineering societies, whose Committee on International Relations has taken a very active part in planning for the Congress and in arranging for United States participation. This Congress will be the first in this hemisphere to be inclusive of all branches of the profession and will bring together for the first time representatives of engineering societies, engineering educators and engineering research organizations of the three Americas. Preceding the Congress there will be a meeting in Sao Paulo, Brazil, at which the groundwork will be laid for the creation of a Pan American Union of Engineering Societies for the entire hemisphere. The Pan American Engineering Congress offers an opportunity of putting into immediate effect the recommendations of Point Four of President Truman's inaugural address which proposes to make available engineering know-how of the United States to other countries which are in great need of this knowledge to improve their present economic status.

Looking into the future, it may be that supplying this technical knowledge to other lands will require training in our engineering colleges fully as broad in the technical fields as now, but probably with a broader basis in the humanistic-social field, aiming toward living and working in foreign fields. The opportunity now exists, as never before, for the engineering profession of the three Americas to work together to the end that from such cooperation there may result lasting benefits to the peoples of all countries of the hemisphere. In this way we can contribute our share to the world's present greatest need, which is a firm and lasting peace.

College Notes

Appointment of two professors to the faculty of Division of Engineering at **Iowa State College** was announced by Charles E. Friley, president. George R. Town, formerly manager of Engineering and Research, and assistant secretary of the Stromberg-Carlson Company, has been named professor of electrical engineering and associate director of the Engineering Experiment Station. He replaces J. D. Ryder, who resigned to become head of the electrical engineering department at the University of Illinois.

David F. Smith was appointed professor of chemical engineering, and will, in addition, serve as senior chemical engineer in the Institute for Atomic Research. Smith was director of research development and control and a member of the board of directors of Johnson and Johnson from 1942 until coming to Iowa State. He directed a broad program in such fields as rubber, resins, plastics, paper, textiles, adhesives, cosmetics, pharmaceuticals, and new drugs.

Academic Calendars

By D. B. PRENTICE

Director, Scientific Research Society of America, New Haven, Conn.

The question of whether to assign four or five years to the undergraduate engineering curriculum has been argued many times, and opinion is still divided, with the majority favoring four years. The plan of six or seven years for a combined arts college and engineering school program has a few supporters and some cooperative curricula offer the equivalent of four and a half or five years of academic work. The four year period, however, has held its own for a century as the most popular schedule leading to the bachelor's degree. Variations have come and some have remained but probably ninety per cent of the accredited engineering curricula currently require four years.

Academic years are traditionally divided into terms or semesters. Frequently the time table of the engineering school must conform to that of the university. However, independent engineering schools are not unanimous in preferring either two or three divisions of the college year. In general the total weeks are the same and thirty-six seems to be a fairly standard length. Three twelve-week terms or two eighteen-week semesters are generally accepted, although seventeen and even sixteen week semesters are used by a few institutions. Semesters are preferred by those who object to short courses, and terms appeal to those who like to finish course examinations before the Christmas holidays. Inasmuch as the date of Easter varies from year to year there is no corresponding regular annual advantage at the end of the winter term.

Educational institutions have been criticized for inefficient use of plant and equipment because of the long summer vacation. There is good reason for a short holiday period at Christmas and perhaps a few days in early spring. Sustained mental effort, which should be demanded of students in college, is fatiguing and periodic interruptions probably improve the performance of learners and teachers. A three-month interval between spring and fall semesters or terms, however, is hardly necessary for recuperation.

Arguments for the summer vacation include opportunity to earn part of college expenses for the students and to carry on research or secure industrial experience for the faculty. In many cases the first is not necessary and the second is not done. In fact the majority of students do not seek summer jobs and the majority of teachers do little full time research.

It is true that many institutions operate summer terms, which provide extra compensation for the faculty and opportunities for the students to shorten the total calendar time required to complete degree requirements. A few institutions now make faculty contracts on the basis of the normal academic year plus a short summer session or a full summer session in alternate years. Salaries can be higher under this plan and a reasonable amount of time is still available for research. But no accredited college, so far as the writer knows, deliberately schedules full academic time of its students. All required engineering curricula are limited to thirty-four or thirty-six weeks of classes between September and June with extra summer work optional, except for surveying or similar practice courses

in one or two of the undergraduate years and the alternating academic periods of the cooperative program.

On a time basis, therefore, the standard academic program is less than seventy per cent efficient. It probably reflects a carry-over from the days when the United States had an agricultural economy and "working on the farm" was essential. The short college year is characteristic in all countries and in each case doubtless derives historically from the same agricultural labor requirement. At least in the United States this demand no longer exists.

Is it possible to arrange a time-table that retains the advantages of the present standard and avoids its inefficiencies? The following simple adjustment is offered as a solution; three fifteen-week terms, a ten-day holiday at Christmas, a four-day interruption in the spring, and five weeks of vacation in the summer. For 1948–49 this calendar would have been as follows;

Fall term, Sept. 9–Dec. 22
Christmas holiday, Dec. 23–Jan. 2
Winter term, Jan. 3–April 15
Spring holiday, April 16–April 20
Spring term, April 21–Aug. 3
Summer vacation, Aug. 4–Sept. 7
Fall term, Sept. 8–Dec. 21
Christmas holiday, Dec. 22–Jan. 1

The advantages of this calendar can be summarized as follows;

A. time efficiency of 86.5 per cent; forty-five weeks of school in each calendar year.
B. terms of nearly semester length, thus avoiding short courses.
C. fall term final examinations completed before Christmas holidays.
D. five weeks vacation in the vacation season. Time enough for travel or some concentrated research.
E. fall term commencing after Labor Day and corresponding to football season.
F. completion of requirements for first degree in three calendar years.
G. higher salaries for faculty.

While eighteen-week semesters can be considered standard a number of accredited engineering colleges operate on seventeen-week periods. Eight semesters of seventeen weeks each total 136 weeks. Nine terms of fifteen weeks each total 135 weeks; which may be considered practically equivalent to the former.

If a week per term be allowed for examinations the engineering course of twelve twelve-week terms has 132 weeks of instruction. The proposed schedule allows for 126 weeks with one-fourth less terminal points; not a dangerous reduction.

If it is felt that the present undergraduate curriculum should be lengthened the proposed time-table makes that feasible without taking more years of the student's life. For example, eleven terms can be completed and commencement held by late April of the fourth year after graduation from high school. Students from this schedule would thus have a slight advantage job-wise over those on the standard program. And they would have had 165 weeks of instruction, an increase of 15 to 20 per cent over the normal requirements.

An alternative arrangement would make the undergraduate curriculum ten terms, or 150 weeks, long and two terms, or thirty weeks, of instruction could be at the graduate level. This plan would permit the student to secure bachelor's and master's degrees in but little more total time than is normally required for the first degree.

The three 15-week term plan has received one criticism which can hardly be considered serious; the freshman, sophomore, junior, senior labels do not fit nine terms or three years. I imagine the undergraduates might be permitted to solve that problem.

The financial readjustments of a longer academic year are interesting, especially

to the faculty. It seems reasonable to charge the same tuition for work leading to the bachelor's degree whether offered in 8 semesters or 9 terms. For example, if tuition is $225 per semester a student pays $450 a year or $1800 for his entire course. Under the proposed plan the equivalent tuition would be $200 per term or $600 a year.

Let E stand for endowment income per student per year, A for administrative and general expense and O for operating and maintenance expense per faculty member per year; both on the normal two semester basis. Assume a 10 to 1 ratio of students to faculty, a fixed student capacity and let F equal average faculty salary. The operating equation, assuming no profit or loss, is for each faculty member:

$$10E + 10 \times 450 = A + O + F. \quad (1)$$

For three 15-week term operation the items A and O will increase only slightly; for heating load, care of grounds, etc., will not change and most operating and administrative personnel are on an eleven month basis anyway. Assuming a 10 per cent increase in these items we get equation

$$10E + 10 \times 600 = 1.1A + 1.1O + F'. \quad (2)$$

Subtracting (1) from (2) we get

$$1500 - \frac{A + O}{10} = F' - F. \quad (3)$$

If teaching salaries are two-thirds of the total educational budget, then $A + O$ must equal $F/2$.

Substituting in (3) we get:

$$1500 - F/20 = F' - F,$$

or

$$F' = .95F + 1500. \quad (4)$$

This represents an increase for any salary average less than $30,000. For an average salary of $5000 (instructor to professor, weighted) the proposed change indicates a possible increase of $1250 per year in the average, or one-fourth. A change of the average by this amount could mean, in a faculty of normal rank distribution, increases in salary of $2100 for professors, $1000 for assistant professors and $700 for instructors.

Before	
10 professors @ $7000	$70,000
8 asst. prof. @ $4750	38,000
12 instructors @ $3500	42,000
30 @ $5000	$150,000

After	
10 professors @ $9110	$91,100
8 asst. prof. @ $5750	46,000
12 instructors @ $4200	50,400
30 @ $6250	$187,500

Under the suggested plan there will be three classes in college instead of four. This means three-fourths as many subjects to be taught simultaneously with one-third more students in each. In general this should mean more efficient use of faculty time. Possibly the gain would permit equally satisfactory instruction with, say, a 12 to 1 student-faculty ratio. The further possible increase in salaries is calculated below:

$$10E + 4500 = A + O + F. \quad (1)$$

$$12E + 12 \times 600 = \frac{1.1 \times 12}{10}(A + O) + F''. \quad (5)$$

Subtracting (1) from (5) we get

$$2E + 2700 = .32(A + O) + F'' - F. \quad (6)$$

Substituting for $(A + O)$

$$2E + 2700 = .16F + F'' - F$$

or

$$F'' = .84F + 2E + 2700. \quad (7)$$

Substituting $5000 for F and $300 for E,

$$F'' = 4200 + 600 + 2700 = \$7500. \quad (8)$$

The resulting average salary is an increase of $2500 or 50 per cent. The

distribution of salaries then might take the following form:

10 professors @ $11,100	$111,000
6 asst. prof. @ $6000	36,000
9 instructors @ $4500	40,500
25 @ $7500	$187,500

It should be noted that smaller values of E, and therefore of F, will produce larger relative increases in faculty salaries. This is to be expected, of course, as endowment income is not affected by time-tables or student faculty ratios.

Perhaps the suggested change from a 10-to-1 to a 12-to-1 ratio requires analysis. Assuming a unit of 300 students the change would decrease faculty from 30 to 25. With the average student distribution among classes of approximately $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, and $\frac{1}{3}$ from senior to freshman year we would have classes about as follows: seniors, 50; juniors, 60; sophomores, 75; and freshmen, 100. Each of these groups must be increased slightly to give a total of 300. If 20 students are considered a maximum per section for instruction we shall have a minimum of 5 sections of freshmen, 4 of sophomores, and three each of juniors and seniors, a total of 15. Irregularities of enrollment may increase this to, say, 20 sections. If the students' schedules average 18 credits with 14 recitations and four 3-hr. laboratory or drawing periods per week as a typical distribution, we get a clock-hour teaching load of $20 \times 26 = 520$. For a faculty of 30 the average individual clock-hour teaching load would be 17.3 per week with an average student-hour teaching load of about 260.

Assuming the proposed calendar of three 15-week terms per year and the same total enrollment we might get a distribution of 67 seniors, 99 middlers and 134 freshmen. Irregularities would be relatively less important and we might have 4 senior, 5 middle and 7 first-year sections, or a total of 16. With the same schedule requirement as before we get a total clock-hour teaching load of $16 \times 26 = 416$. For a faculty of 25 the average individual clock-hour teaching load would be 16.7 per week.

The suggested three 15-week term year has been considered informally by a few engineering college teachers, but, so far as the writer knows, has never been adopted by a faculty. It seems to have enough advantages to merit discussion. Time does not permit the presentation of a specific sample curriculum for nine terms; but one advantage is immediately obvious, for mathematics can be finished in the first three periods.

College Notes

Because of the vastly expanding national program of irrigation and reclamation there has been under development during the past several years at **Colorado A. & M. College** an Irrigation Institute with the objective of offering graduate training in all phases of irrigation engineering. The favorable location of the College among the irrigated areas of the West, and the long and noteworthy experience of the irrigation staff, combine to form a unique opportunity for advanced study and research. Integrated with this program is the work being done in the Hydraulics Laboratory, which was formerly used by the U. S. Bureau of Reclamation in connection with the studies for Hoover, Grand Coulee, Norris and other notable dams. Dr. Maurice L. Albertson is in charge of work in the hydraulics Laboratory. The Civil Engineering Department of the Engineering Division, which administers the graduate work in irrigation engineering, is under the direction of Dr. Dean F. Peterson, who just came to A. & M. College from Utah State College.

The Role of Universities and Colleges in Research as Reflected by the Steelman Report

By N. A. CHRISTENSEN

Director of School of Civil Engineering, Cornell University

Introduction

The impact of the recent war has convinced practically all thoughtful Americans that our future welfare, both in time of peace and in time of war, depends upon our research accomplishments. This fact is evident from four important investigations each resulting in reports: first, Dr. Bush's report entitled "Science the Endless Frontier," second, by the extensive hearings in Congress on the National Science Foundation Bills, third, by the Steelman Report entitled "Science and Public Policy," and fourth, by the more recent report of the President's Commission on Higher Education. It is true that the last mentioned report has a somewhat broader concern than science alone. Its attitude of viewing the entire citizenry of the United States as our most fundamental resource is no doubt correct. But, this report like the others emphasizes the overwhelming importance of a vigorous scientific advance.

The Steelman Report was prepared by the Presidential Research Board composed of Reconversion Director John R. Steelman as Chairman and the Secretary of Commerce, the Secretary of the Interior, the Secretary of the Navy, the Secretary of War, the Federal Loan Administrator, the Chairman of the Federal Communications Commission, the Chairman of the Tennessee Valley Authority, the Chairman of the National Advisory Committee for Aeronautics, and the Director of the Office of Scientific Research and Development as members of the committee. Because of the membership of this Board, this report may be considered as a recommendation of the Executive branch of our government of the essential features of the research expansion proposed in the United States. The outcome of the recent election which returned the governmental control to the Democratic Party has increased the probability that this report will serve as a basis for legislation which will implement federal expansion of the research in the United States.

The Steelman Report entitled "Science and Public Policy" is composed of five volumes, totaling about 1000 pages. Volume one entitled "Science and Public Policy" is a summary of the basic recommendations and investigations of the committee.

Volume two entitled "The Federal Research Program" is a composite of several more detailed reports, one from each of the various federal agencies engaged in research. The relative importance of each of these agencies in the year 1947 can be seen by examination of the following table taken from Volume 2.

Volume 3 entitled "Administration for Research" is also a composite of reports one from each of the federal agencies having the responsibility of administration of research activities. The scope of the federal program is indicated by the following table taken from this volume.

RESEARCH AND DEVELOPMENT AGENCIES

A. Agriculture Department
1. Office of Experiment Stations.
2. Bureau of Animal Industry.
3. Bureau of Dairy Industry.

FEDERAL RESEARCH EXPENDITURES, BY AGENCY, FISCAL YEAR 1947
(In thousands)

Agency	Expenditures	
	Amount	Per cent of total
Grand Total	$623,930	100.0
Navy Department	262,000	42.0
War Department	237,000	38.0
Agriculture Department	31,328	5.0
Interior Department	30,358	4.9
National Advisory Committee for Aeronautics	27,000	4.3
Federal Security Agency	13,236	2.1
Commerce Department	10,494	1.7
Federal Loan Agency (RFC)	4,699	.8
Tennessee Valley Authority	3,654	.6
Veterans' Administration	2,523	.4
Federal Works Agency	822	.1
Smithsonian Institution	309	(1)
Treasury Department	220	(1)
Federal Communications Commission	200	(1)
Maritime Commission	87	(1)

[1] Less than 0.05 per cent.

4. Bureau of Plant Industry, Soils, and Agricultural Engineering.
5. Bureau of Entomology and Plant Quarantine.
6. Bureau of Human Nutrition and Home Economics.
7. Bureau of Agricultural and Industrial Chemistry.
8. Agricultural Research Center (Beltsville).
9. The Forest Service.
10. Soil Conservation Service.
11. Production and Marketing Administration.
12. Farm Credit Administration.

B. Commerce Department
1. National Bureau of Standards.
2. Civil Aeronautic Administration.
3. Weather Bureau.
4. Coast and Geodetic Survey.
5. Office of Technical Services.

C. Department of the Interior
1. Geological Survey.
2. Bureau of Mines.
3. Fish and Wildlife Service.
4. Bureau of Reclamation.
5. National Park Service.

D. Navy Department
1. Office of Naval Research.
2. Bureau of Aeronautics.
3. Bureau of Yards and Docks.
4. Bureau of Medicine and Surgery.
5. Bureau of Ships.
6. Bureau of Ordnance.

E. War Department
1. Army Technical Services
   a. Quartermaster.
   b. Signal Corps.
   c. Ordnance
   d. Chemical.
   e. Engineers.
   f. Medical.
   g. Transportation.
2. United States Air Forces [1]
   a. Air Materiel

F. Federal Security Agency
1. U. S. Public Health Service.
2. Food and Drug Administration.

G. National Advisory Committee for Aeronautics
1. Lanley Memorial Aeronautical Laboratory.
2. Ames Aeronautical Laboratory.
3. Flight Propulsion Research Laboratory.

H. The Smithsonian Institution
1. Research Divisions.

I. Atomic Energy Commission
1. Research Division.

J. Federal Works Agency
1. Public Foods Administration.

K. Federal Communications Commission
1. Engineering Department.

L. Federal Power Commission
1. Bureau of Power.

M. Veterans' Administration
1. Medical Research Division.

N. Treasury Department
1. Bureau of Engraving and Printing.
2. Bureau of the Mint.
3. Coast Guard.

O. Federal Loan Agency
1. Office of Rubber Reserve (RFC).

P. Tennessee Valley Authority
1. Operating Divisions.

Volume 4 entitled "Manpower for Research" emphasizes the fact that the relatively small number of scientists is the

[1] Does not reflect changes arising from the National Security Act of 1947 which established Departments of the Army, Navy, and Air Force.

limiting factor upon research expansion. In fact, after reading the whole report one is left with the impression that the proposed expansion was set as high as possible, consistent with the supply of scientists. Since colleges and universities are the primary sources of these trained personnel, this volume is of special interest to the administrators of institutions of higher education.

Volume 5 entitled "The Nations Medical Research" calls attention to how thin medical research has been in the past; to recent great advances growing out of the stimulus and support of war funds and to medical problems for the attention of medical researchers in the future.

Since this 1000 page report is literally filled with facts and figures, it seems impossible to make a detailed review. The discussion in this paper, therefore, will be limited to the major recommendations found in Volume 1 of the report.

Principal Recommendations

For a basis of discussion the eight principal recommendations of the report are quoted below:

1. That, as a Nation, we increase our annual expenditures for research and development as rapidly as we can expand facilities and increase trained manpower. By 1957 we should be devoting at least one per cent of our national income to research and development in the universities, industry, and the Government.

2. That heavier emphasis be placed upon basic research and upon medical research in our national research and development budget. Expenditures for basic research should be quadrupled and those for health and medical research tripled in the next decade, while total research and development expenditures should be doubled.

3. That the Federal Government support basic research in the universities and nonprofit research institutions at a progressively increasing rate, reaching an annual expenditure for at least $250 million by 1957.

4. That a National Science Foundation be established to make grants in support of basic research, with a Director appointed by and responsible to the President. The Director should be advised by a part-time board of eminent scientists and educators, half to be drawn from outside the Federal Government and half from within it.

5. That a Federal program of assistance to undergraduate and graduate students in the sciences be developed as an integral part of an over-all national scholarship and fellowship program.

6. That a program of Federal assistance to universities and colleges be developed in the matters of laboratory facilities and scientific equipment as an integral part of a general program of aid to education.

7. That a Federal Committee be established, composed of the directors of the principal Federal research establishments, to assist in the coordination and development of the Government's own research and development programs.

8. That every effort be made to assist in the reconstruction of European laboratories as a part of our program of aid to peace-loving countries. Such aid should be given on terms which require the maximum contributions toward the restoration of conditions of free international exchange of scientific knowledge.

Discussion of Recommendations

Recommendations 2, 3, 5 and 6 call for a 4 to 8-fold expansion of basic research within the colleges and universities themselves. Recommendations 1, 2, and 4 would require the colleges and universities to double the number of American scientists and research engineers, exclusive of university personnel by 1957. The roll of the colleges and universities during the next eight years is, therefore, twofold; first, to expand scientific activities and organization within the institution of higher learning 4 to 8 times, and second, during the same period double the total scientists in the United States.

Recommendation No. 1 is that we expand our research as fast as possible. No top restrictions are placed, but as a minimum performance it is estimated that by 1957 we should be spending at least 1 per cent of our national income which at that time is estimated at approximately two and one-half billion dollars. This is approximately eight times the total expenditure which was made for research in the United States in 1940. It is approximately twice as much as was spent in the year 1947. In 1940 there were between 80 and 90 thousand scientists and research engineers. It is estimated that in 1957 we can have as many as 270 thousand scientists and research engineers. The proposed minimum expenditures, therefore, are related to the number of men that can be supplied. As a matter of fact, the board which prepared the Steelman Report recognized that the manpower supply was the limiting factor to the whole expansion. The minimum expenditure recommendation, therefore, was probably based on the estimated possible supply of scientists and research engineers. The burden of doubling the number of scientists and research engineers in the next 8 years rests directly upon the colleges and universities in the country.

Recommendation No. 2 deals with distribution of the National Research and Development budget to the various types of research. For purposes of discussion the report classifies research into four categories: basic research, background research, applied research, and development. The intention of this classification is clear and it will not be necessary for the purpose of this paper to become involved in the arguments aroused by attempts to define the boundaries between these classifications. The important thing for the colleges and universities to note is that basic and background research has not received its just share of attention during the war period nor since. Applied research has not only used up much of the fundamental knowledge resulting from basic research but has exposed gaps in our basic research frontier. It is in the institutions of higher education where these gaps are to be closed.

Recommendation No. 3 would increase basic research funds from the government to universities and nonprofit institutions to 250 million by 1957. When this amount is added to the estimated basic research funds from other sources the total would be about 440 million in 1957. In 1947 the amount expended was about ¼ this figure or 110 million dollars. Since research is getting more and more expensive a budget four times as large would not mean four times the volume of research, but it may require four times as many scientists in the universities because the teaching load will increase simultaneously with the research load.

In many of the smaller land grant schools the principal research funds are those of the Agricultural Experiment Stations. The total research expenditure of the U.S.D.A. in 1947 was about 31 million which is roughly ⅛ of the proposed federal expenditure of 250 million for basic research in 1957.

A similar amount of 31 million came from the states as matching money, which means that in 1947 the research funds to the Agricultural Experiment Station was about ¼ of the federal money proposed for basic research in 1957. Now if the 250 million is distributed similarly to the Agrictultural Experiment Station funds, it would increase the federal research money to small institutions by four times and change the center of gravity of the work from Agriculture to basic science. This would call for reorganization of the research programs in these small institutions. How the money is finally distributed will have a profound effect upon all American institutions of higher learning. The report recommends that a National Science Foundation be created and that the responsibility of distribution be vested in this foundation.

National Science Foundation

Recommendation No. 4 is that a National Science Foundation be established.

According to the report the principal duty of this Foundation would be to distribute the federal grants for basic research. This is a much narrower function than was proposed by several of the National Science Foundations Bills considered by Congress. In spite of this restriction, the Foundation would still have a profound effect upon the development of our colleges and universities. The report emphasizes that a portion of the basic research funds should be used to strengthen the weaker but promising colleges and universities and thus increase our total scientific potential. There are clearly two points of view which might be taken in the distribution of funds by the N.S.F.: first, to give all the money to universities and organizations having strong research organizations in order to get the maximum immediate benefit, and second, to distribute the funds upon a geographic and population basis in order to better develop the long time scientific potential of the country. The path which will be followed will probably be between these two extremes. The N.S.F. will probably develop a relationship to the colleges and universities similar to the one which now exists between the Office of Experiment Stations of the U.S.D.A. and the Land Grant Colleges.

If the N.S.F. is independent of the Office of Experiment Stations (and this seems probable), each of the schools receiving funds from both sources could probably function best by having a dual type of research organization. One part would do the agricultural experimentation work as in the past and the new part would do the basic research work with money from the National Science Foundation.

If the foundation activity is limited to basic research, probably less than 10 per cent of the nations research program will come under their scrutiny. Under these conditions one may also expect extensive arguments as to whether or not research is basic or applied. And the definitions drawn will probably be affected by whether or not the agency concerned wishes to operate under the general jurisdiction of the National Science Foundation.

Recommendation No. 5 seems to be a corollary to recommendation 3. If all the potential scientists are to be trained, it seems certain that the economic barriers now preventing the college education of over half of our qualified young men and women will need to be removed. It is very difficult to see how these barriers can be removed for the potential scientists without, at the same time, removing the barriers for all other worthy students. This point of view is further emphasized and elaborated in the recent report prepared by the President's Commission on higher education. One ought not overlook the fact that if these barriers are removed, the teaching load in the universities will increase by over 100 per cent within the next decade.

Recommendation No. 6 is also a corollary to recommendation No. 3. If we attempt to carry this recommendation out on the scale proposed, we are likely to find difficulty in the procurement of the necessary items. It is quite likely that every institution of higher education which engages seriously in research will need to establish an instrument shop equipped with fine machines and manned by highly skilled workmen.

Recommendation No. 7 seems a little contrary to many statements found within the report. In many places throughout the report adequate coordination and cooperation between the government agencies is inferred. And yet, this recommendation No. 7 clearly indicates that the Presidential Research Board felt that better coordination and cooperation could be attained by the establishment of a federal committee. When one contemplates the size and complexity of government research, it is not surprising that such a committee is recommended.

The relationship between this committee and the National Science Foundation, as well as the relationship of the army, navy and air forces together with other federal agencies to the National Sci-

ence Foundation, is an important one. At this time most of the money for basic research as well as applied research is channeled through the military organizations. If the N.S.F. is to acquire its projected importance, it will have to become the principal source for federal money for basic research. A determined personnel for the N.S.F. and the help of Congress may be necessary if the N.S.F. is to become firmly established. The foundation's primary purpose is to guide and promote the nation's development in basic research and in order to do this it must control the purse strings to most of the basic research funds.

Recommendation No. 8 is a magnanimous gesture. It seems to recognize the unity of the world and if our prosperity is to be permanent, all nations of the earth must also prosper and benefit by advancing science. There is some difficulty encountered when attempts are made to define "peace-loving countries." Our definition of this term would likely depend upon our frame of reference. At the present time, no doubt, those countries joined with us in opposing Russian aggression would all be considered peace-loving countries. It is also quite likely that all countries affiliated with Russia would not be considered in this category. In spite of this, the Russians are still human and as individuals no doubt hope for peace. It may be that freedom-loving or non-aggressive countries would be more easily defined. At least, we may say that science prospers best in an environment of freedom and it would be a poor economic risk to put our money into dictator controlled science.

Since this is a meeting of engineering administrators, it may be appropriate to discuss the effects of the Steelman Report Recommendations which specifically effect engineering education. The report shows the scientific manpower pool of 1947 is 137,000 of which about 42,000 are research engineers, 30,000 chemists, 15,000 medical and health scientists, 15,000 other physical scientists, 12,000 agricultural scientists, 9000 other biologists, 8000 physicists and 6000 unclassified scientists. Of the 42,000 research engineers roughly ¼ are in colleges and universities, ½ in industry and ¼ in government employment. The engineering group is not only the largest of all, but shares with the chemist group the distinction of having adequate representation in each of the three following fields of endeavor: higher education, industries and federal organizations. Research engineers are not only distributed in all types of research organizations but also in all types of research from basic to development research. This group is the largest of all and can serve as a "cement" to bind together American research organizations as well as the different kinds of research. They can help to fill the large gap between purely basic research and the end application of basic research known as development.

For many years the engineering divisions of the Land Grant Colleges tried to establish a chain of experiment stations similar to the Agricultural Experiment Stations. These efforts were first defeated by the agricultural interests in the L.G.C. system itself. By the time this opposition was won over to support the movement, the American Association of Universities had grown strong enough to stop any legislation which applied only to the L. G. Colleges. The Engineering College Research Association then came into existence which tended to bring together the L.G.C. and A.A.U.

If this welding of the interests of the Land Grant College Association and the American Association of Universities can be completed and the gap between pure scientists and applied scientists bridged, the recommendations of the Steelman report can be accomplished.

Conclusion

The stage for organized university and college action seems to be set. These institutions and only these institutions seem to hold the keys to make possible the realization of objectives of the Steelman

Report. The need for research expansion is overwhelmingly recognized by our nation. All four of the important surveys mentioned in the first part of this paper strongly recommend the expansion of science, on on broad principles these four reports support each other. Most of the differences of opinion seem to revolve around the question, "who is to call the plays." It seems likely that if all institutions of higher learning could agree and jointly formulate a basic research policy of national scope, it would be accepted by the American people. The Steelman report emphasized the fact that applied research and development are now "scraping the bottom of the basic research barrel." It is hoped that the institutions of higher education will be able in the near future to effect a research program which will prevent the "barrel" from becoming bone dry.

A.S.E.E. Reprints Available

The following reprints from the JOURNAL OF ENGINEERING EDUCATION are available at 25¢ each in quantities of less than 10; 20¢ each for 10 to 50 copies; and 15¢ each for more than 50 copies. The date of original publication in the JOURNAL is indicated in parenthesis. Orders should be sent to the Secretary. Checks should be made payable to the American Society for Engineering Education.

1. Report of the Committee on Ethics of Interviewing Procedures (March, 1949)
2. Partnership with Industry by C. J. Freund (November, 1948)
3. Accrediting Technical Institutes by H. P. Hammond (May, 1948)
4. A Survey of Teachers' Salaries in Engineering Schools and a Comparison of These with Salaries Paid to Engineers in Non-Technical Employment and with Teachers in Other Professional Schools. (The complete report will not be published in the JOURNAL)
5. Report on Present-Day Salaries of Members of the Instruction Staffs of Engineering Schools in the United States and Canada (September, 1947)
6. Report of the Committee on Transfer of Students from Emergency Institutes (September, 1947)
7. The Outlook in the Demands for and Supply of Engineering Graduates (September, 1947)
8. Report of the Committee on Academic Tenure, Professional Service and Responsibility (June, 1946)
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Summary of the Report of the Committee on Faculty Salaries

By WILLIAM C. WHITE, Chairman

Dean of Administration, Northeastern University

Introduction

In June 1948, Dean S. S. Steinberg, then serving as Vice President of A.S.E.E. in charge of the Engineering College Administrative Council, appointed a Committee on Faculty Salaries[1] to make a survey of the salaries currently paid to teachers in engineering schools and to compare these with the salaries paid to teachers in other professional schools and to engineers in non-teaching employment. This project had been suggested by Dr. D. C. Jackson as a result of his study[2] of engineering teaching salaries made under A.S.E.E. auspices in 1946–47. The following is a summary of the 70-page printed report issued by the Committee in June 1949 with funds generously provided by the Carnegie Corporation of New York.

During the summer of 1948 negotiations were carried on with officers of organizations similar to A.S.E.E. in other professional fields for the purpose of obtaining their cooperation in gathering the necessary data. Cordial responses indicating a willingness to participate were received from officers of the Association of Collegiate Schools of Architecture, the American Association of Collegiate Schools of Business, the American Association of Dental Schools, and the Association of American Law Schools. A persistent but unsuccessful effort was made to enlist the participation of the Association of American Medical Colleges.

By early fall of 1948 a questionnaire had been perfected by the Committee with the assistance of other representative engineering school administrators throughout the country. This basic instrument was subsequently adapted to the specific needs of other professional school groups and reprinted in slightly differing forms for distribution to all of their constituent institutions.

In addition to basic salary data, the Committee obtained information from professional schools with regard to extra payments for overload services during the academic year, for summer school teaching, and for the conduct of sponsored research both during the regular academic year and during summer periods. Institutional policies with respect to fundamental unsponsored research and with regard to consulting activities by staff members were also explored.

Questionnaires were sent to all institutions whose names were provided by the professional school organizations previously mentioned with the request that they be filled out and returned as soon as possible to the Secretary of the Committee.

In response to the original request and one or two follow-up letters appropriately spaced, usable replies were received as indicated in the following table. This gratifying response enhances the representative character of the data and indi-

[1] H. H. Armsby, C. L. Eckel, T. K. Glennan, T. Saville, M. G. Kispert, Secretary, W. C. White, Chairman.

[2] Report on Present Day Salaries of Members of Instruction Staffs of Engineering Schools in the U. S. and Canada, June 1947.

cates a widespread interest in the question of faculty salaries in professional schools.

Professional School Group	Number Mailed	Number Returned	Per Cent Returned
Engineering	154	123	80%
Architecture	50	43	86%
Business	58	54	93%
Law	103	93	90%
Dentistry	47	26	55%

Treatment of the Data

Since this salary survey was conceived as a comparative study, it was obviously necessary to decide upon some unit as a common denominator. A preliminary analysis of returned questionnaires indicated that the plans under which teachers are paid vary considerably among institutions and that it would be necessary to adopt some arbitrary basis for comparisons. Slightly more than a third of the engineering schools reporting (45 out of 123) pay their teaching staffs wholly or partly for 12 months' service with from 4 to 6 weeks' vacation. About 19% of the teachers reported fall in this classification. The remaining engineering schools (78 out of 123) base annual salaries upon the academic year of 9 or 10 months, leaving the staff free during the summer to accept other employment.

In view of this situation, the Committee decided to use an academic year of 10 months, including 4 to 6 weeks' vacation, as the standard base upon which to report all teaching salaries in the professional schools. Since teachers on 12-month contracts are called upon for service during 6/5 of the standard work year that was adopted in this report for comparative purposes, their salaries were uniformly reduced by 1/6 in compiling the data.

This procedure differs from that of the Jackson report two years ago, but it appears to represent more nearly the mean among institutional practices as revealed in the summer term data available to this Committee. Dr. Jackson did not have comparable data. He reduced 12-month salaries on a sliding scale as follows: department heads—0, professors and associate professors—1/5, assistant professors and instructors—1/4. These changes in computing procedure will tend to show increases in salaries of department heads over those reported by Dr. Jackson which

TABLE II

COMPARATIVE DATA ON BASE MONTHLY SALARY RATES OF ENGINEERING TEACHERS AND PROFESSIONAL ENGINEERS IN NON-TEACHING EMPLOYMENT AT FOUR LEVELS OF EXPERIENCE

Experience Level in years assumed for the several academic ranks	*A Highest Monthly Salary of lower 25% Prof. Engr. as rpt'd by EJC—1946	B Data in Col. A inc. by 20%	**C Highest Monthly Salary of lower 25% of Eng. Tchrs. 1948–49	*D Median Monthly Salary of Prof. Engs. as rpt'd by EJC—1946	E Data in Col. D inc. by 20%	**F Median Monthly Salary of Eng. Tchrs. in 1948–49	*G Lowest Monthly Salary of upper 25% Prof. Engrs. as rpt'd by EJC—1946	H Data in Col. G inc. by 20%	**I Lowest Monthly Salary of upper 25% of Eng. Tchrs. 1948–49
25–29 (Profs.)	395	474	500	511	612	580	716	859	670
20–24 (Assoc. Profs.)	409	491	410	481	577	440	623	748	500
12–14 (Asst. Profs.)	354	425	350	385	462	380	521	625	420
7–8 (Instructors)	311	373	290	360	432	300	423	508	320

* Table 1.2a, page 8, "The Engineering Profession in Transition."

** One-tenth of annual salary on a ten-month base. Only about 57% of the teaching staffs receive the equivalent of twelve such payments from their institutions.

are somewhat less than have actually occurred; but increases in salaries of other academic ranks will appear to be greater than have actually taken place. This comment applies only to that 19% of the salaries reported by institutions on a 12-month basis.

Another factor which should be borne in mind in making certain comparisons with the Jackson report is that he used *medians of average* salaries, whereas this Committee reports *medians of median* salaries. The latter measure of central tendency was chosen because it is less affected by extreme values and because it permits better comparisons with engineering salaries contained in the E.J.C. Report on "The Engineering Profession in Transition." [3]

In its full Report—copies of which may be obtained from A. B. Bronwell, Secretary of A.S.E.E.—the Committee has presented basic salary data for engineering schools in 1948–49 following the same general pattern worked out by Dr. Jackson under which the material is classified both by geographical regions and by types of institutions.

Because of the smaller number of institutions involved and the fact that classification by region and by type of institution would not be particularly meaningful, the Committee tabulated the data from schools of architecture, business, dentistry, and law for the country as a whole. In all other respects the salaries of teachers in these professional schools were analyzed in the same way as those of teaching staffs in schools of engineering—using a ten-month academic year inclusive of 4 to 6 weeks' vacation as a base, and reducing all salaries reported on a 12-month plan by 1/6.

Mindful of its assignment to conduct a comparative study, the Committee sought to tabulate basic salaries in such a way as to reveal the maximum of useful information without identifying any institution with a specific set of data. Accordingly in the tabulations each institution is indicated by a code number with the maximum, minimum, and median salary which it reported for each academic rank. The data are arrayed in descending order of magnitude of the maximum salaries reported, each horizontal line representing the data from a single institution.

Beside every tabular view of salaries in each academic category is a summary which shows:

1. {the number of institutions reporting / the number of teachers reported
2. {how many teachers at how many institutions are paid for 12 months of service
3. {the median of maximum salaries reported by institutions / the median of minimum salaries reported by institutions / the median of median salaries reported by institutions
4. {the individual maximum salary reported / the individual minimum salary reported / the individual median salary reported

In making comparisons with data from Dr. Jackson's 1947 report, the institutional medians listed under 3 above may be useful if the differences in procedure previously mentioned are borne in mind. The individual medians were calculated on the assumption that data reported were reasonably evenly distributed throughout the range and are of course only close approximations. When compared with the institutional medians they indicate whether the preponderance of teachers are serving at the higher paying or lower paying institutions and they may be compared with medians of engineering salaries in non-teaching employment.

Comparisons of Salaries in Professional Schools

In this summary space does not permit reproducing the detailed tabulations in

[3] "The Engineering Profession in Transition," Engineers Joint Council, 1947, Andrew Fraser.

TABLE III

RANGE BETWEEN MAXIMUM AND MINIMUM SALARIES* WITH CALCULATED MEDIANS** FOR TEACHERS IN VARIOUS RANKS IN FIVE TYPES OF PROFESSIONAL SCHOOLS IN 1948–49

Schools	Professors (Including Dept. Heads)				Associate Professors				Assistant Professors				Instructors			
	Maximum	Minimum	Range	Ind. Median	Maximum	Minimum	Range	Ind. Median	Maximum	Minimum	Range	Ind. Median	Maximum	Minimum	Range	Ind. Median
Architecture	12000	3000	9000	5800	8000	3600	4400	4600	8000	2800	5200	3800	4000	2000	2000	3200
Business	14000	3800	10200	6500	9500	3500	6000	5000	7000	3000	4000	4000	5400	1900	3500	3100
Dentistry	10800	3000	7800	6600	7300	3800	3500	5300	6300	2500	3800	4300	5400	1000	4400	3100
Engineering	12000	3700	8300	5800	9500	3000	6500	4400	6800	2500	4300	3800	4700	1700	3000	3000
Law	15000	3500	11500	7100	8000	3600	4400	5000	7000	2500	4500	4200	7500	2400	5100	3600

* Based on 10 months of service; salaries reported for more than 10 months of service have been reduced by 1/6.

** These are the individual medians for the country as a whole, calculated from the data reported by taking into account the number of teachers at each institution.

the Report for individual institutions. Comparative information as to the relationships among salaries in the various professional schools is given in Table III which shows individual maximum, minimum, and median salaries among all the teachers reported in the several fields represented in the study.

There is a very wide range in the salaries paid to teachers in each of the five professional school groups in all academic ranks as shown in Table III. Reasonable differences in teachers' salaries for a given rank because of ability, experience, location of the school, institutional standards, and other factors are to be expected. But the salary ranges shown in Table III seem to be excessively broad especially since the great majority of the institutions represented are offering accredited curricula. Teachers in the higher paying institutions command substantial salaries; staff members at institutions whose salary schedules are at the lower end of the range do not appear to be adequately paid for the kind of service they ought to render. It is of course inevitable that the effectiveness of instruction will vary from institution to institution and salary alone is not a fair index of instructional efficiency, but if the quality of the work carried on in professional schools varies on a scale at all proportional to that of the salaries paid to members of teaching staffs the situation is not sound.

Examination of the tabulated data in Parts Three, Four, and Five of the complete Report should enable each institution to find its own position as to salaries in the educational scene and thus to judge whether its salary scale is a reasonable one. Local economic conditions, opportunities for teachers to supplement their incomes through professional practice, summer teaching or research, the quality and amount of service that members of the staff are expected to give, and the financial status of the institution—all these are additional factors that need to be taken into account when the adequacy of salaries at a particular institution is being considered.

Table IV shows the relative over-all status of teachers in the five types of professional schools studied. In comparison with salaries paid to teachers in other professional schools, salaries of engineering teaching staffs at the median level are at the bottom of the range in all ranks except that of department head. Salaries of teachers in architec-

TABLE IV

COMPARISON OF ANNUAL SALARIES OF FACULTY MEMBERS IN PROFESSIONAL SCHOOLS
Maximum, Minimum, and Median Salaries Reported by Institutions for 1948–1949

(All data are on a 10-month basis; 12-month salaries have been reduced by 1/6)

Professional Schools	No. of Institutions Rpt'g	No. of Teachers Rpt'd	Percentage of Tchrs. Paid 12 months' serv. whose Sal. 20% higher than here shown	% Tchrs. whose '48 Summer Service Augmented Inst. Sal. by about 20%	Total % Tchrs. whose 12 mo. Inst. Sal., '48–9 were about 20% higher than here shown	Medians of Maxima					Medians of Minima					Medians of Media				
						Department Head	Prof. (including dept. hds.)	Associate Professor	Assistant Professor	Instructor	Department Head	Prof. (including dept. hds.)	Associate Professor	Assistant Professor	Instructor	Department Head	Prof. (including dept. hds.)	Associate Professor	Assistant Professor	Instructor
Archit.	43	516	12%	36%	48%	6400	6000	4800	4000	3400	6300	5000	4300	3600	2850	6400	5300	4500	3850	3050
Bus.	54	2252	9%	43%	52%	6000	6500	5000	4300	3500	5300	4950	4400	3500	2800	5600	5800	4750	4000	3100
Dent.	26	388	74%	2%	76%	6900	6800	5650	4800	3800	5000	5400	4600	3800	2800	6250	6200	5350	4400	3300
Eng'g	123	8541	19%	38%	57%	6200	6300	4800	4000	3500	5000	4800	4000	3300	2700	5700	5200	4300	3700	3000
Law	93	813	11%	44%	55%	7050	6450	5200	4400	3600	7050	5500	5000	4000	3500	7050	6050	5150	4200	3600

ture are only slightly higher, then come salaries of business school staffs, with the salaries in law schools and schools of dentistry at the top. These two last mentioned schools are definitely at the graduate level whereas the first three are generally concerned with both undergraduate and graduate work. If a comparison were possible between the graduate instructional staffs in engineering schools and the instructional staffs in schools of law and dentistry, it is our belief that the respective salaries would be more nearly of the same magnitude.

The differences in medians of maxima reported by the five types of professional schools are much less pronounced but the salaries of teachers in dental schools and law schools are still at the top of the range. At median of minimum levels, salary scales for engineering teachers are again somewhat lower than those for staff members in other professional schools. On the other hand the percentage of engineering teachers whose salaries are actually 20% higher than tabulated because of service to their institutions during the summer is 57%, which is higher than that of any of the other professional groups except teachers of dentistry where the percentage is 76%.

Individual medians in every academic rank except that of professor on a country-wide basis are very close to the institutional medians. For professors, in all of the professional school groups studied, the individual medians range from $400 to $1050 above the institutional medians ($500 in Schools of Architecture, $700 in Schools of Business, $400 in Schools of Dentistry, $600 in Schools of Engineering, and $1050 in Schools of Law), presumably indicating that the preponderance of teachers in this rank are employed by the higher paying institutions.

Although accurate comparisons are not possible for reasons previously stated, it appears that the salaries of engineering teachers have generally increased in the two-year period since the Jackson Report: roughly 10% on the whole—slightly more than this for instructors, slightly less for assistant professors—and with considerable variation percentagewise among the institutions reporting. In fact the spread in salaries of engineering teachers among institutions, the variety of factors related to their compensation such as privileges of graduate study, extra pay for evening teaching, opportunity for research activity and consulting practice, type of environment, geographical location, housing conditions, prospects for advancement, and similar matters make it difficult to generalize in a meaningful way upon the inadequacy or adequacy of the situation as a whole.

Comparison of Salaries of Teachers in Engineering Schools with Salaries of Engineers in Non-Teaching Employment

The most difficult part of the Committee's assignment was that of comparing salaries paid to teaching staffs in engineering schools with those of engineers in non-teaching professional employment. With the resources at its command, the Committee could obtain reliable data regarding 1948–49 teaching salaries directly from engineering schools, but to collect comparable current information with respect to salaries of non-teaching engineers was not feasible.

Mindful of the comprehensive and authoritative study of salaries paid to professional engineers prepared by Mr. Andrew Fraser as part of the 1946 Survey of the Engineering Profession sponsored by Engineers' Joint Council, the Committee decided to utilize the basic data of that report as initial reference points, and to try to find out what had happened to the salaries of engineers in industry since the autumn of 1946 with a view to applying appropriate correction factors.

Such a procedure was obviously not ideal, but since no more promising and yet practical alternative presented itself, the Committee felt that this plan should be tried. Accordingly a letter was sent early in January, 1949, to about 200 companies, located throughout the United States and employing large numbers of engineers, with the request that they indicate the percentage increase in salary that had occurred between August, 1946, and the end of 1948 for:

(a) newcomers to the profession
(b) engineers with 5 to 6 years' experience
(c) engineers with 12 to 15 years' experience
(d) engineers with 25 to 30 years' experience
(e) engineers with more than 30 years' experience

The eighty-six replies that were received came from all sections of the country and are estimated to represent several thousand engineers because the respondents were mostly large industrial corporations. A tabulation of these replies shows that the median increase of salaries during this period was 20% in all five categories. It is interesting to note that the cost of living as reflected in the Consumer Price Index for Moderate Income Families in Large Cities compiled by the U. S. Bureau of Labor Statistics increased by approximately this same percentage over the two-year period ending in September, 1948, although it has since dropped a few points.

The Committee is cognizant of the prevailing impression that the salaries of younger men have increased percentagewise more than those of the mature engineers and realizes that a more comprehensive survey might show this to be true. The present survey shows that about half of the 44 companies who submitted complete replies think that they have increased salaries all along the line by about the same percentage and that the other half believe that they have increased the salaries of their more experienced engineering personnel somewhat less than the salaries of younger ones.

Moreover the available information on increases in engineering salaries in industry is based on a rather small sample. It is also true that while practically all who replied answered the questions with respect to the first three categories, only about half furnished information about the last two which pertained to engineers of long standing. Many respondents said they found it very difficult to differentiate at the upper experience levels between general salary increases attributable to the economic situation and merit increases based upon individual achievement. In addition it is likely that the estimates of the percentage increases in the more experienced groups may be unconsciously biased upward because people tend to think in terms of absolute rather than relative changes.

For these reasons the Committee doubts the validity of the median increase in salaries of 20% at all five experience levels during the two year period beginning in the fall of 1946. The increase of 20% for men ten years out of college is confirmed by the April, 1949, report of the General Survey Committee of the Engineers' Joint Council. It seems likely, therefore, that this figure is a reasonably sound approximation for the upward trend of salaries paid to younger engineers, but it is to be doubted that the salaries of the more experienced engineers have increased percentagewise by that amount, although they have unquestionably increased somewhat.

Comparison with E. J. C. Survey

The problem of comparing current teaching salaries in engineering schools with salaries paid to engineers as reported in the E. J. C. Survey of 1946 is complicated not only by the difficulty of determining a suitable percentage of upward correction for data at each experi-

ence level, but also by a number of other factors such as the following:

(1) Teaching salaries are reported on a ten-month basis inclusive of four to six weeks' vacation; whereas salaries of non-teaching engineers are generally paid on a twelve-month basis with from two to three weeks' vacation.

(2) Teaching salaries are reported in terms of academic rank, whereas E. J. C. data are tabulated in terms of years of experience.

(3) The data on teaching salaries were reported by institutions and are presumably representative of teaching staffs as a whole. The data compiled by E. J. C. were obtained from information voluntarily supplied by individual members of six national professional societies, and although there were some 47,000 returns, there is the possibility that these may have come in greater numbers from the more successful segment of the engineering profession than from the less well paid practitioners. And finally, the information as to increases in salaries since 1946 comprises company estimates and not factual data submitted by individuals.

Tabulation as a Rough Comparison

With all of these obstacles to direct comparison, the Committee obviously could not prepare any meaningful and valid graph showing relationships between the salaries of engineering teaching staffs and those of engineers in non-teaching employment. There remained the possibility of tabulating available data which, although not susceptible to direct comparison, would show in a very general way the relative salary status of engineering teachers and engineering practitioners.

Table II is an attempt to do this. In it the monthly salary rates at the 25th, 50th, and 75th percentiles of professional engineers at four experience levels are reproduced directly from Table 1.2a on page 8 of the "Engineering Profession in Transition." These original data from the E. J. C. Report appear in Table II as columns A, D, and G. Adjacent to these figures in columns B, E, and H are the same data increased by 20% in all cases. This is a purely arbitrary tabulation for purposes of discussion because, as has been already pointed out, the Committee does not feel warranted in drawing reliable conclusions from its limited study of recent trends in salaries paid to engineers in industry.

Columns C, F, and I show monthly salary rates at the 25th, 50th, and 75th percentiles of teachers in engineering schools in the four usual academic ranks. These percentiles were calculated from the median salaries reported for the country as a whole, taking into account the number of teachers reported by each institution. Annual salaries were divided by 10 in all cases to arrive at the monthly salaries shown in these columns.

Although the data on teaching salaries are believed to be reliable *in terms of academic rank*, they are of course not directly applicable to the experience levels with which they have been identified in Table II. In order to make a truly valid comparison between salaries of teachers and practitioners one would need data from the engineering colleges in which salaries were reported by age level rather than by academic rank.

Not having such data, the Committee tried to make a rough approximation that might be helpful in thinking about relative rates of pay for teachers and practitioners. The average ages of faculty members in each of the four academic ranks in the six institutions represented by members of the Committee (Case Institute of Technology, University of Colorado, University of Maryland, Massachusetts Institute of Technology, New York University, and Northeastern University) were found to be very nearly the same and therefore assumed to be typical of the general situation. There

seemed to be no point in making a more elaborate study of this matter since the only purpose to be served was to arrive at some reasonable approximation that would enable rough overall comparisons to be made.

For the six institutions, average ages of staff members in the several ranks were found to be as follows: professors—49 years, associate professors—44 years, assistant professors—36 years, and instructors—30 years. Since the median age for entering the profession of engineering was reported by E. J. C. to be 23 years, the experience level for each academic rank was determined by subtracting this age from the average ages of teachers stated above. In this way it is possible to effect an approximate relationship between the E. J. C. data and the monthly salaries of engineering teaching staffs.

It should be borne in mind that only about three-fifths of the engineering teachers are paid for 12 months' service to their institutions. The remainder are paid for an academic year of nine or ten months, although many of these undoubtedly supplement their incomes through summer employment for which the institutions assume no responsibility.

After making due allowance for the inadequacies of the data, which have been previously pointed out, the Committee believes the evidence indicates that monthly salaries of teachers in engineering schools are, on the whole, somewhat below those paid to engineers of comparable experience in non-teaching employment. It is true, however, that many engineering teachers have opportunities to supplement their annual income in ways that are not available to engineers in non-teaching employment.

Except for professors at the median and lower 25% levels the salaries of engineering teachers lag behind or at least have not passed beyond the rates reported two years ago by E. J. C. for professional engineers of roughly comparable experience. How much the salaries of engineers in non-teaching employment have increased since the fall of 1946 at various experience levels is open to question, but it is generally known that there have been increases all along the line.

At present teaching salaries compare least favorably with salaries of engineers in general at the instructor level. The nearest approaches to parity with the salaries paid to engineers in non-teaching employment occur at the level of full professor.

College Notes

California Institute of Technology announces the appointment of two new members to its Engineering Division. Dr. Jack E. McKee, who has been associated with the firm of Camp, Dresser, and McKee, sanitary engineers of Boston, Massachusetts, will come to the Institute as Associate Professor of Sanitary Engineering and Caleb W. McCormick, formerly with C. F. Braun & Company and Dames & Moore, soil mechanics and foundation engineers, will come as Instructor in Civil Engineering.

Robert L. Shurter has been appointed the first director of a newly created division of social-humanistic studies at **Case Institute of Technology.** The new division has been created to direct the interdepartmental cultural courses introduced in Case's new curriculum. Dr. Shurter has been professor of English and head of the department of language and literature since 1946. He has been on the Case faculty since 1930.

Report of the Committee on Selection and Guidance

By O. W. ESHBACH, *Chairman*
Dean of Engineering, Northwestern University

It is now eight years since President Cullimore, retiring chairman of the Committee on Orientation of Freshmen of the Society for the Promotion of Engineering Education, wrote to his successor, Dean R. L. Sackett, who was also chairman of the Committee on Student Selection and Guidance of the Engineers' Council for Professional Development, proposing that under Dean Sackett's chairmanship the two societies combine their efforts to give professional and sustained effort to the solution of their mutual problem of reducing student eliminations from college by better selection and early and better guidance.

Your Committee feels that it is appropriate, because of change of sponsorship during the last year, to review briefly the origin of the Measurement and Guidance Project, its experience during four years of War, the four years following the War, its present status, and to draw tentative conclusions and make recommendations for future progress.

Origin

Prior to President Cullimore's suggestion, both the SPEE and the ECPD had made considerable progress in the appraisal of their own philosophies, methods and goals. Engineering educators had long recognized the chronic problem of assisting high school teachers and students to give better guidance to those presumably interested, and particularly to those qualified to study engineering.

Among the colleges many had been active in schemes for freshman guidance. Dean Sackett and President Cullimore were particularly impressed by the work of Dr. A. B. Crawford at Yale, who, at the time, had summarized his experience in a book entitled "Predicting College Achievement." After several conferences with him, Dr. Crawford suggested that Dr. Russell S. Bartlett be retained to extend and test the studies already begun. This work could be described as an attempt to determine the mental differences between arts, science, and engineering students enrolled in the common freshman year at Yale. Arrangements were made to give a battery of tests to arts and engineering freshmen at the opening of school in the fall of 1941. The following schools participated:

The Universities of Florida, Missouri, Tennessee, Texas
Northwestern University
Newark College of Engineering
Pasadena Junior College

In the initial trial a set of six tests was administered to about 1800 entering freshmen in arts and engineering, and a modified battery of tests of the same general content were given to about 1000 high school juniors residing in or near Newark. The six tests, listed by name, were as follows:

I. Verbal Comprehension
II. Artificial Language
III. Quantitative Reasoning
IV. Spatial Visualizing Ability
V. Mathematical Aptitude
VI. Mechanical Ingenuity

The tests and progress records for the students were assembled and carefully checked. Students who withdrew during

[1] Presented at the General Session at the Annual Meeting of the ASEE, Troy, N. Y., June 22, 1949.

the freshman year, or whose records were incomplete, were eliminated from the study, with the result that complete records were available for 979 students. A report on the study was printed in the JOURNAL OF ENGINEERING EDUCATION, Vol. 34, April, 1944. Without going into the details of results, it is significant to note that the intercorrelation between the last four tests was quite high, varying from .536 to .686. Only two of the tests, Quantitative Reasoning, and Mathematical Aptitude, showed a correlation above .500 with freshman grade averages. The most predictive tests of success in the cultural aspects of the engineering curriculum were Test I, Verbal Comprehension, and Test III, Quantitative Reasoning, with validity efficients of .40 and .43, respectively.

The Committee originally planned to administer objective achievement examinations at the end of the freshman and sophomore years for purposes of correlation between grade-point averages and the original tests. As this work was about to be initiated, Dr. Bartlett resigned to accept a position as Headmaster of the Gunnery School and plans had to be changed.

At this time the War was beginning to exert influence upon engineering education, which re-focused the attention of educators on the problems of student selection and curricular organization.

The Carnegie Foundation for the Advancement of Teaching was acquainted with the work of the ECPD and the SPEE and had also organized a Graduate Record Office to study collegiate and graduate education. Through the interest of President Robert E. Doherty of ECPD, the Foundation became interested in sponsoring the continuation of the experiment begun by Dean Sackett and President Cullimore. The project was known as the Measurement and Guidance Project, sponsored jointly by the ECPD, the SPEE, and the Carnegie Foundation. The work centered in the Foundation's Graduate Record Office.

Organization and War Experience

The agencies jointly sponsoring the measurement and guidance project agreed on the formation of three committees: (1) an advisory council, (2) a consultant committee, and (3) a measurement committee, to cooperate wherever possible with the committees of SPEE and ECPD, whose activities were related. The general aims were to develop a series of predictive tests; to determine the validity of these tests in predicting success, particularly in the freshman year; to develop achievement examinations in subjects characteristic of engineering curricula; and to validate these achievement examinations.

It was realized that the study was being undertaken at a hazardous time. Problems of selection were not normal. Thousands of students were enrolled in the ASTP and the V-12 programs. Few of the civilian students were permitted to continue their education beyond their freshman and sophomore years.

Nevertheless, with the cooperation of these institutions,

California Institute of Technology
Carnegie Institute of Technology
State University of Iowa
Massachusetts Institute of Technology
University of Michigan
Newark College of Engineering
North Carolina State College of Agriculture and Engineering
Northwestern University
Rose Polytechnic Institute
University of Tennessee
University of Texas

and under the direction of Dr. K. W. Vaughn, of the Carnegie Foundation, the project was launched and the present tests known as the "Pre-Engineering Inventory—Revised Form A" were developed. The type of test, and the time to administer each of them is as follows:

	Minutes
Information Blanks and Interest-Hobby Questionnaire	20
Test I. General Verbal Ability	35
Test II. Technical Verbal Ability	25
Test III. Ability to Comprehend Scientific Materials	90
Test IV. Ability to do Quantitative Thinking	70
Test V. Ability to Comprehend Mechanical Principles	40
Test VI. Spatial Visualizing Ability	30
Test VII. Ability to Comprehend Social Science Materials	40

They were first used in the fall of 1943 and revised in the summer of 1944. A summary of the number of tests conducted was reported by Dr. Vaughn in the JOURNAL OF ENGINEERING EDUCATION, Vol. 39, June 1946. The number of participating institutions and tests given in each of the three years, ending with the close of the War, are as follows:

NUMBER OF PARTICIPATING COLLEGES AND STUDENTS TESTED

	1943–1944	1944–1945	1945–1946
Number of Institutions	9	29	32
Number of Students	1703	6208	12,307

Measurement and Guidance Project

In addition to this number, 15,000 other students took all or part of the Pre-Engineering Inventory Tests. These students were tested under varying circumstances, mainly in connection with the armed services training programs, and were not classified as regular freshman engineering students. It must be recognized that, up until the close of the war, no satisfactory opportunity, due to lack of educational continuity, was presented to make proper studies of the validity of the tests, which was one of the basic objectives. The experience did provide opportunity to test a total of about 35,000 students under controlled conditions.

Post-War Program

During the first year after the War, under the direction of Dr. Vaughn, plans were made to establish norms for the engineering inventory tests and also to improve methods of reporting. Simultaneously, sophomore achievement tests were developed and experimental forms made available for the following year. Tests for senior engineers, and a high school series of guidance tests, were also proposed.

It should be emphasized that the summer and fall of 1946 provided an unusual, and probably the first, opportunity of carrying through a program of appraisal. Obviously it was the first time that any assurance could be had for the normal education of engineering students. The Project took advantage of this opportunity by making a special analysis of the examinations of 9994 freshmen who were tested during the summer and fall of 1946, and issued in May of 1947 what is known as the "Norms Bulletin." The features of this Bulletin included the establishment of a scaled scoring system, the selection of standard samples, and the segregation of private and public colleges, veterans and non-veterans, and those with previous college training from those whe entered as normal freshmen. The standardization group on which the scaled score system was based included 7187 freshman engineering students, none of whom had been previously enrolled in college. The majority of these students, in the ratio of five to two, were accepted by public colleges; likewise, the majority in approximately the same ratio were veterans.

During the year thirty-nine engineering schools participated in the testing program. The number of students tested was 32,098, involving 627 testings, as indicated in the table below:

NUMBER OF STUDENTS TESTED IN 1946–1947

Group		Number of Testings	Number of Students
A	PEI Institutional Testing (38 colleges)	87	20,786
B	PEI National Testing	429	2,732
C	PEI Special Testing	100	2,041
D	Achievement Testing—Sophomore	7	2,180
E	Achievement Testing—Experimental	4	4,359
		627	32,098

This year also marked the inauguration of the sophomore achievement tests with the participation of seven institutions. Among the purposes of the latter program was the study of the validity of the Pre-Engineering Inventory Tests by obtaining correlations between the tests, grade-point averages, and PEI scores. To date, insufficient data are available to draw any conclusions. The Project really has not had time to have a fair chance.

The first results, published in the spring of 1947, gave the following correlation scores on the several PEI tests with grade-point averages during the first semester of study in ten colleges of engineering:

		Range	Median
Test I.	General Verbal Ability	.16–.50	.38
Test II.	Technical Verbal Ability	.25–.55	.47
Test III.	Comprehension of Scientific Materials	.41–.65	.55
Test IV.	General Mathematical Ability	.51–.71	.62
Test V.	Comprehension of Mechanical Principles	.30–.55	.39
Test VI.	Spatial Visualizing Ability	.22–.42	.35
Test VII.	Understanding of Modern Society	.25–.53	.41
Composite Score		.44–.68	.62

In the fall of 1947 the number of participating institutions increased to fifty and the post-War development program continued as previously organized until 1948. At that time the Carnegie Foundation withdrew from all testing activities, and the Project, together with the College Entrance Examination Board and certain professional groups, entered into an arrangement with a newly-formed agency called the Educational Testing Service. Later in the year Dr. Vaughn severed his connections with the Carnegie Foundation.

After considerable discussion and investigation, the ECPD and the ASEE entered into an arrangement with the Educational Testing Service so that the Measurement and Guidance Project might be carried on. Thus, during the recent year, the Educational Testing Service has administered the Pre-Engineering Inventory Tests and assumed financial responsibility for the Project. Both the ASEE and the ECPD are represented on an advisory committee to the Testing Service. This committee is composed of representatives of the three bodies involved.

It should be appreciated that the transfer of the Project to a new agency, however experienced in testing methods, involved a number of difficult problems which could neither be quickly nor easily resolved. The first of these involved an analysis and projection of the costs, in which it appeared that the Project could not be self-supporting. While this problem was being studied, the Educational Testing Service proceeded with the administration of the Pre-Engineering Inventory tests as heretofore and established a program of national administration. This provided for giving the tests at approximately 160 centers in forty-seven states. A bulletin of information was prepared and distributed to the colleges and high schools establishing the dates of March 5 and June 25, 1949, for the administering of the tests. It was contemplated that the Pre-Engineering Inventory would be given to the fresh-

man classes at those institutions which wished to use them for guidance and experimental purposes. It was estimated that a charge of $2.00 a student would be needed to cover costs and that the institution would either pay the cost itself or transfer it to the students. The national testing service, at established centers, would make available pre-admission examinations for the institutions who wished to use the tests for this purpose. The cost was set at $7.00 a student, to be borne by the student.

During the first year under the new sponsorship, the Project continued the program as projected in the preceding year. The number of tests administered during 1947–1948 and 1948–1949 were as follows:

	Number Tested	
	1947–1948	1948–1949
1. Pre-Engineering Inventory Institutional Enrollees	11,267	8,889
2. Pre-Engineering Inventory Institutional Applicants	4,643	
3. Pre-Engineering Inventory National Program (and State Program) Applicants	4,252	3,793
4. Pre-Engineering Inventory Special Programs (probably applicants)	406	91
5. U. S. Merchant Marine Cadet Corps Testings	1,539	1,573
6. Engineering Achievement Tests	7,105	2,583
Grand Total	29,212	16,929

In addition, the number of schools participating in the Achievement Tests increased to seventeen. Validation studies were also continued and a report made to the Advisory Council and the ECPD.

While every attempt has been made to carry on the Project as originally planned, grave concern has been expressed by members of the Advisory Committee and by institutional representatives as to the practicability and financial success of the tentative proposals. This situation was immediately anticipated by your Committee, but no information from experience was available. It appears that a projection of income and expense for the current year, even at increased rates, would cause the Project to operate at a deficit which is prohibitive.

Although no satisfactory solution is apparent, in anticipation of continued conferences, your Committee obtained the opinion of the participating institutions as to their intention of continuing the Project, the degree to which they would use the examinations if available for entrance purposes, and the extent to which they were able to appraise their value. On the basis of replies received, your Committee believes that institutions will cooperate as they have in the past to achieve the purpose of establishing adequate tests for guidance of freshmen, reliable tests for admission purposes, achievement tests at the sophomore and senior levels, and guidance tests for high school juniors. It is recognized that this must be done in a practical way at justifiable costs, with full appreciation that quick results may not be obtained. While the administrative problems in the immediate future have not been clarified, certain conclusions and recommendations are presented.

Conclusions and Recommendations

Most of the Pre-Engineering Inventory Tests are given after admission and administered by the cooperating schools, the object being to use them for guidance purposes, check their admissions against national norms, and help to establish the validity of the tests for predicting success in college.

Only a few of the colleges use the tests for the selection of freshmen. This is to be expected, because most of the state institutions are required to admit students on high school certificate. For this reason it may be anticipated that the national testing centers program will not be used sufficiently to support the program financially.

The best predictive single test is the mathematics test (IV). The composite score which is the sum of the scores of Tests II, III and IV shows promise of simplifying the tests, reducing the number, and the time of administration.

Many of the private schools feel that high school grades, combined with tests administered by their own admissions offices, produce satisfactory results for admission purpose.

If the program is to continue and succeed, which will require many years of experimentation, it must be done on a sound financial basis with ample funds for research. This means wider participation and simplification of tests.

Your Committee asks for the continued cooperation and support of the Measurement and Guidance Project by the engineering schools, and makes the following recommendations to the ECPD Committee on Student Selection and Guidance and the Advisory Committee of the Educational Testing Services:

1. Make the present battery of Pre-Engineering Inventory Tests available without scoring service at $1.00 per student, and with scoring service at $2.00 per student.
2. Terminate the National Testing Center service and arrange with the College Entrance Board for an additional optional test so as to cover essentially the present P.E.I. Tests.
3. Continue the development of sophomore achievement tests and make them available on the same basis as P.E.I. to participating institutions with and without scoring service.
4. Consider future development of senior achievement tests in the several professional fields of Engineering.
5. Continue validations tests and periodically establish national norms.
6. Encourage the development of Aptitude, Interest and Personality Tests for Guidance at high school level.

Discussion

Dr. Chauncey (Educational Testing Service): Mr. Chairman, Members of the A.S.E.E.: I am delighted to have the opportunity to meet with you and talk briefly with you today, even though I learned I was to do so only ten minutes ago. I am particularly glad because there are some problems concerned with the Measurement and Guidance Project in Engineering Education which I would like to talk over with you.

A year-and-a-half ago, when we took over the administration of the tests under the program of the Measurement and Guidance Project we did so with a great deal of enthusiasm because we felt that a good start had been made and that there was a great opportunity for developing tests that would be very useful to engineering schools—tests for selection of students, tests for the guidance and placement of students, and tests to measure the achievement of students.

We immediately undertook to establish a contractual and working relationship with the A.S.E.E. and the E.C.P.D. That took a little time because of the usual difficulties of tripartite relationships. But it was accomplished about a year ago. Advisory committees were set up and we have met, from time to time, both with the Selection and Guidance Committee of A.S.E.E. and with the special Advisory Committee representing both societies and E.T.S.

First we tackled procedures for the administration of the Pre-Engineering Inventory and we feel that we have improved them. More important, we conducted studies that had been neglected previously. We made reliability studies of both the Pre-Engineering Inventory and Engineering Achievement Tests. We made analyses of the relationship between the total score and the part scores; we made item analysis studies which would lead to the development of new forms of the Pre-Engineering Inventory, both analyses against scores on the tests themselves and also item analyses against out-

side criteria—against grades in engineering schools—which are particularly helpful in making a strong, valid test.

We also made validity studies at twelve of the engineering schools. And I am glad to report that these studies, in general, show that the Pre-Engineering Inventory is doing a very good job.

We made, at two engineering schools, in addition, validity studies correlating success on the individual sections of the Pre-Engineering Inventory with scores on the engineering achievement tests. They also indicated that the Pre-Engineering Inventory was a useful instrument, not only for general prediction, but also for differential prediction in the different courses of the engineering curriculum of the first two years.

In looking around for project directors, we decided that one of the most important areas in which to get a project director was engineering. I am glad to say that we have been able to secure the services of a man who has been at Purdue and who was the secretary of a committee of the A.S.E.E. in early years, A. Pemberton Johnson. He is to join our staff on July 1.

Therefore, we looked forward with enthusiasm to what we could do on this project and started right in to do the very best job we could. Unfortunately—and here is where the rub comes—our enthusiasm has been dampened, not by any lack of confidence in what could be accomplished, but by the fact that there is not the financing to accomplish it. When the project was handled under the Carnegie Foundation, it was supported constantly by the Carnegie Foundation. Every one-dollar fee for the institutional testing program was matched, in effect, by a one-dollar fee that came out of either the A.S.E.E., the E.C.P.D. or the Carnegie Foundation, all of which contributed towards the project.

So when we undertook the program, it was clear, since we had no funds with which to support it ourselves, that the fees would have to be raised. The fees for the institutional program were raised to $2.00 and for the national program to $7.00. Not unnaturally, the change in fees discouraged some institutions from participating, and whereas two years ago some 32,000 students took the Pre-Engineering Inventory, this past year only about 16,000 took it. Therefore, there has been a marked drop in income.

Along with the reduction in income there have been increased expenses due to the additional work we have done which we hoped would lead to the improvement of the tests and their usefulness to engineering schools. We, therefore, have a deficit of $31,000 for this fiscal year. And we, as I said, have no funds with which to finance it. Something must be done. Dean Eshbach has told you what seems to be the practical solution.

In the first place, we should drop the national program. The national program was administered, this year, on three occasions—in December, in March and it is to be administered in June. The number of candidates in December, if I remember correctly, was around 200 and in March around 1900 and around 600 in June. You cannot administer tests all over the country, set up centers at perhaps 160 different places over the country and test that number of students, without a much larger fee. The Medical College Admission Test, for example, is administered to around 15,000 students and the fee is $10. The College Board examinations are administered in April to around 40,000 students and the fee is $12. So it is just impossible to conduct a national program for the Pre-Engineering Inventory with so few candidates and at such a low fee.

Therefore, to take care of the institutions that have used the national program it was decided to try and get the College Board to add a test to its regular battery which would measure abilities tested in the Pre-Engineering Inventory which were not covered in Board tests. With this new test that the College Board has now agreed to add as an option, all of the factors measured in the Pre-Engi-

neering Inventory will be measured in the College Board tests so that institutions which do want a national supervised administration can get it through the College Board examinations.

But then there are the institutions that want the examinations for placement and guidance purposes, administered on the so-called institutional basis. As many institutions apparently could not afford the $2.00 fee, the alternative seemed to be to say, "All right, we will let them have the examinations for the $1.00 fee providing they do their own scoring." It so happens that in the state universities there is almost always a testing office which has a test-scoring machine and a perfectly competent staff to do the scoring, the use of which involves no cost outlay. The testing office frequently is glad to do such additional work to show that it is providing needed services. It seemed that this would be a satisfactory solution and the examination could thus be made available for a $1.00 fee. On the other hand, if scoring was desired, it could be done centrally by E.T.S. at an additional fee.

The general problem, as I see it, is a lack of unity of purpose among the engineering schools. It is not unnatural and, perhaps, it may be for the best. But it does prevent a strong program of development of tests in the field of engineering. Unless the engineering schools get together, work together with a central testing agency and support the program, it is obviously going to be impossible to provide the kinds of tests that I feel confident could be developed if there was adequate support.

In the meantime, I think it may be best to let the use of the tests subside and make them available to those institutions that want them. We, on our part, will be conducting general research in areas that are at least collateral to the engineering problem: guidance tests, aptitude tests and personality tests for use at the high school level or at college level. In the development of these tests we are likely to learn things which will be helpful in preparing tests specifically for engineering when the time comes that there is sufficient interest and enthusiasm and financial backing to support the Measurement and Guidance program in the way that I, personally, would like to see it supported.

In the News

RECORD OF 430,000 COLLEGE DEGREES GRANTED DURING ACADEMIC YEAR

Federal Security Administrator Oscar R. Ewing announced that colleges and universities throughout the United States conferred approximately 430,000 degrees during the year ending June 30, 1949—an all-time high. This estimate by the Office of Education, Federal Security Agency, is based upon returns from about 1000 of the Nation's 1200 degree-granting institutions. Earl James McGrath, U. S. Commissioner of Education, said of the survey findings, "This year's estimated total of 430,000 college degrees tops last year's previous high record of 319,000 and practically doubles the number in the pre-war peak year of 1939–40. The total includes 375,000 bachelor's or first professional degrees, and 55,000 advanced degrees, either master's or doctor's. Thirty-eight per cent more bachelor's or first professional degrees were granted in 1948–49 than in 1947–48. The number of doctor's degrees rose 29 per cent over the preceding year, and the number of master's degrees 20 per cent." Fifty-two per cent of all degrees granted during the 1948–49 academic year were earned in private institutions, the Office of Education report disclosed.

The Lamme Medal

Twenty-two distinguished educators have received the Lamme Medal. The Committee is seeking nominations for the twenty-third award, which will be made at the Annual Convention in June 1950. To get membership participation we must begin almost as soon as an award has been made.

A number of years ago The Lamme Award Committee, consisting of twelve members of the Society, set up the following rules for making the award:

1. Achievements which can be taken as proof of excellence in teaching or as having contributed to the art of technical training, will be given major consideration.
2. Only those achievements will be considered which seem to have the possibility of lasting influence or which have sufficiently stood the test of time.
3. Books, articles, contributions to method and research, which have a beneficial effect upon the teaching of engineering, will be given considerable weight in making the decision.
4. Participation in the work of Engineering and Educational Societies is not necessary for eligibility. Such participation, however, will be given due consideration if it has led to definite and recognized results in bettering technical education.
5. Achievements outside of the field of teaching, such as employment in industry, consulting work, inventions, etc., will be considered as of secondary importance in making the award.
6. Administrators in engineering schools are eligible. Only that work of Administrators, however, will be considered which has led to definite and recognized improvements in method of teaching or in the art of technical training.
7. Emeritus Professors are eligible.

Nominations should emphasize the contributions of the candidate to these major objectives. Concise statements of achievements are much more valuable to the Committee than a series of recommendations from former students and present acquaintances. Listings in Who's Who in Engineering, and such publications, give some information regarding achievements but material of this type will not give the Committee the needed information to make a valid judgment.

Statements made according to the following outline will give the information needed:

1. Preparation for teaching work—school, year graduated, degree, postgraduate work, honorary degrees.
2. Accomplishments as a teacher.
3. Advancement of the art of technical training—books, articles, contributions to method, research, etc.
4. Administrative work in engineering schools.
5. Membership and participation in Engineering and Educational Societies.
6. Engineering practice—employment in industry, consulting work, inventions, etc.
7. Other achievements.

Nominations should be sent to the Chairman of the Committee, Nathan W. Dougherty, University of Tennessee, Knoxville, Tennessee, by January 1, 1950.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1000, together with an engraved certificate. The recipient is selected by a ten-man committee, nine of whom are appointed by the President of the Society. There is also a representative from the Foundation. The Award for 1950 will be presented at the banquet of the annual convention in Seattle, Washington, in June 1950.

The recipient of the Award must have made a significant contribution to the teaching of engineering students and shall have distinguished himself in several of the following ways:

1. Record as a teacher. (Evidence of superior teaching and guidance of students as demonstrated by records of former students, indications of unusual subject matter competence, etc.)
2. Improvements of the tools of teaching. (Textbooks and student notes, descriptions of special courses or curricula, diagrams and models, new laboratory and teaching equipment, etc.)
3. Other activities contributing to the improvement of teaching. (Material relating to the development of teachers in the nominee's department or teachers in general, the development of testing and guidance program for students, the promotion of cooperation with other types of educational units or with industry, coordination of fields of subject matter, etc.)
4. Evidence of high intellectual capacity. (Brilliance of mind as manifested by contributions to literature, degrees and honors received, etc.)

The Award has been established to encourage younger men who have shown by their past record evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before March 1, 1950, to the chairman of the Committee on Award, Dean H. E. Wessman, College of Engineering, University of Washington, Seattle 5, Washington. Nominations must be made on forms available from either the chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

On Teaching Creativeness in Design*

By E. L. MIDGETTE, J. N. MACDUFF and J. MODROVSKY

Polytechnic Institute of Brooklyn

For years industrial employers have been criticizing the "products"—graduates—of engineering schools. For just as many years teachers in the engineering schools have been critical of their own work, themselves, and of the "products" they graduated. In no field has this criticism been stronger from industry, the teachers, and the students graduated, than in the field of "designing mechanical equipment." As a result of this external and internal criticism there is no set of courses in the engineering schools that have been revised more times, or attempted in more different ways.

Each revision has introduced a new "catch phrase" to express the aim or method of approach to the problem. Now a new term has been offered to express the goal, "Creativeness in Design." Certainly this term, as others in the past, will have different meanings to different teachers. In this discussion the term, "creativeness" will be used to mean, "The ability feasibly to combine known elements of mechanisms to achieve a desired result." Stated like this, creativeness is not a new aim for design teachers. However, as the "desired result" mentioned in the definition may be one that either has or has not been achieved before, this creativeness does place accent on equipping designers for "development" rather than "modification" design. Many designers have a "knack" for this type of work, and they are in great demand in industry. Sound, thorough, modification or redesign engineers are more easily obtained. Knowing this, engineering schools and certain industries have in recent years intensified their search for means of supplying this demand.

Each of us has most likely participated in this search in one way or another, and similarly the search has perhaps followed the same pattern: (1) trying to determine the essential characteristics of the good designer and (2) trying to organize the design sequence to best develop these in students.

Characteristics of a Good Designer

The essential characteristics that mark a creative designer are not readily agreed upon. However, any list of these qualities would include: (1) a strong curiosity, (2) a broad fund of general knowledge, (3) good technical ability, (4) capacity to synthesize, (5) proper personal characteristics and (6) industrial experience.

The engineering schools have been doing a very competent job in giving the student good technical ability, but they cannot be expected to furnish the student with industrial experience. Perhaps it is not possible to do justice to all these factors in the time allotted by the usual Engineering Curriculum, but certainly an effort to do so should be made.

Curiosity is of paramount importance in solving specific problems, and in leading the designer to new applications and new products. The defining of the problems associated with a specific design is based upon questions about the design that are inspired essentially by curiosity.

The curious individual will continue to absorb knowledge from the men and machines around him, and will constantly

* Presented at the Annual Meeting of the A.S.E.E. Austin, Texas, June, 1948.

increase his fund of knowledge. This background should include information concerning phenomena, even outside of his major field of endeavor.

Synthesis is possible when curiosity and background are combined with technical ability. An intriguing example of this type of synthesis is seen in the mechanical pen on a direct recording oscillograph. The mechanical magnification of this pen is on the order of 400 to one, and the total weight is probably two grams. It must have been made by a designer who had in his general background a knowledge of the principles of operation of a chain hoist, sufficient curiosity to wonder if he could make a small chain hoist and run it backwards, and sufficient technical ability to carry out his ideas.

Confidence or a belief that a problem can and will be solved is one of the essential personal characteristics of the ideal designer. In addition, if the designer is to be outstanding, he must have the ability to appreciate the position of others, so that he will display the consideration and tolerance vital to group effort.

Assuming agreement on the above the designer teacher must present the design sequence courses so as to enhance the student's probability of developing these qualities.

The Learning Process

The steps in the learning process have been the subject of both abstract and concrete investigation for centuries. An analogy can be usefully made to the generation of a spiral about the origin made by the intersection of two rectangular coordinates axes. When such a diagram is drawn the four quadrants represent four stages in the learning process, and the spiral symbolizes the students progress.

The learning process represented this way, gives the teacher a clue to a method of presenting his material. If the subject is the design this method may be outlined as follows:

First, the student must be acquainted with a new idea, set of conditions, machine or problem, in a general discussion relating it to the students previous experience or knowledge. Second, the teacher can discuss the concept, problem, or machine, in its different aspects, under different sets of conditions and aid the student in his appreciation and appraisal of it. Third, the teacher by example or by discussion will aid the student in using his technical ability to analyze the subject thoroughly, to determine the principles involved, and how they are or may be used, thus developing in the student a critical understanding. Fourth, the student is set to work using this understanding by applying it synthetically with his previous knowledge in the actual solution of a particular problem, or in designing a mechanism or machine for a particular purpose.

The method then demands that mechanism and machine design be treated as integral parts of a single subject. Note that mechanism texts are written primarily to meet the second and third phase of the training process, whereas machine design texts are concerned with the first and fourth. The mechanism text treats subjects analytically and as studies in the motions of massless shapes. Design texts treat subjects as to their place in practice or industry, as having mass, and loads, largely leaving out motion analysis. The good teacher tries to incorporate the essence of both treatments into his design courses, thus giving the student a more complete and rational picture of the problem as a whole.

Methods of Presenting Subject Matter

The educational channels applicable to to the development of the program described above are the usual lecture and discussion periods, homework assignments and design sessions. A laboratory of mechanism and mechanical analysis may be profitably added. The design sessions and the "gadget" laboratory provide excellent opportunities for cultivating the more illusive characteristics

of diagnostic and creative ability so necessary in developing designers.

Lectures are the medium for introducing the various theories of machines. The application of mathematics, physics, strength materials, the philosophy of design, etc., are discussed at this stage. It is recognized that too often the popular theories are necessarily superficial in order to simplify the introduction of subject matter. When such instances are encountered they are emphasized to the student. The limitations of the theories are very often dramatized by extreme applications with their resulting absurdities. The popularity of the maximum shear stress criterion for failure of ductile materials is challenged by reference to membrane stresses in a spherical pressure vessel where, because the principal normal stresses are equal, zero shear stress exists and therefore the capacity is indicated infinite. This technique encourages the habit of critically assessing all proposals rather than accepting the printed word as truth.

It is observed that creative engineers continuously seek new applications of the principles involved in the more routine mechanisms. Frequent efforts are made to highlight presentations of the elements of standard machine components, with reference to actual instances of seemingly alien applications. The mechanics of the belt drive in the machine design curriculum is not taught solely because of the industrial applications of the flat belt. The principles exhibited by the analysis of the belt are more generally important and the students are cognizant of this as the important aspect of belt study. The coil spring clutch is such an application. In this case, the unique relationship between friction torque, angle of wrap, and applied load is exploited fully; but the solution substitutes steel for leather and the concept of load application is completely reversed. The net result is a clutch with a constant capacity despite large variations in the coefficient of friction. The mental process of reapplication of established machine elements by such inversions and the drastic changes in sizes or materials is a common enough technique of creative engineering as to warrant emulation.

Homework, because of its unsupervised nature, is most readily adaptable to practice in the application of theoretical analysis to well defined problems. Homework can be exploited in another direction as well, i.e., training in the art of application and arrangement of machine details. This condition is attained by assignments calling for a critical engineering analysis of the machinery that the student encounters in his every day life. If the student is encouraged to study engineering details of the machinery of his day to day contacts, and to analyze their success as functional designs, he tends to set a life long habit which will continue his development long beyond the engineering school.

A homework assignment covering the engineering analysis of pressure cookers, or a home movie camera, will leave the man with an indelible memory file of quick seals, inexpensive safety valves, intermittent motion mechanisms, surface finishes, etc. Even the lowly aspirin box is a fitting subject for study. The snap lock, details of the hinge, and speculations relative to the fabrication process contribute to the student's encyclopedia of feasible engineering solutions.

The Design Room

In all probability the most effective training for design engineering in addition to the program above is a postgraduate apprenticeship to an experienced designer in an engineering concern. Ideally the engineering program would have to be a very active one dealing with a diversity of products or a single product of a high degree of technological difficulty.

In the engineering office where such an apprenticeship might take place the following characteristic conditions are usually present:

(a) Design problems are given with only the broadest of specifications, leaving to the engineer the responsibility for restating the problem in detail and calculating or "digging-up" the missing data.

(b) The necessary calculations never seem to be exactly covered by published technical matter or theory so the engineer has to resort to judicious assumptions, "stick and string" experimentation, or seek the advice of the more experienced designers and specialists.

(c) Economical design is aided by applying commercially available components where feasible.

(d) The "know-how" within the company is hardly the property of any one man or even of a small group, but rather it is the composite knowledge of the individuals in the organization. Once the apprentice appreciates this, he will find that a satisfactory design requires a series of informal discussions with production engineering, service engineering, sales division, research departments, etc.

A session, conducted by a teacher of good experience, simulates the designer-apprentice relationship. The design problems issued are such as to be concurrent with the lecture subject matter. The strictly analytical problem is avoided in the design session. Only the broad functions are described in the assignment. An important part of the engineering performed by the student becomes a thorough enumeration of the functional requirements.

Little attempt is made to eliminate engineering considerations beyond the scope of the lectures or text. It is important for the student to learn to extend himself beyond his immediate experience. To this end, the engineer in practice resorts to library research, experimentation and personal contacts with specialists. The student is best taught to emulate this process if he is forced into the situation by the design project as it develops. He is encouraged to investigate technical literature in the library and a mechanism and mechanical analysis laboratory is provided for simple experimentation. Members of the faculty must perform the specialist's function.

To complete the simulated industrial procedure the student should refer to commercial literature. Certainly, a stack of design magazines and Sweets catalogs should be considered as minimum for design room references. In addition to the functions described above the teacher must assume responsibility for challenging the student's decisions and solution, encouraging him in the proper direction if his indecision becomes serious, and for assessing the practicability of the solutions.

The Designer's Laboratory

The development of a physical "gadget" laboratory as an adjunct to the Machine Design course is a tremendously intriguing problem. If properly handled, it should prove stimulating and useful to both the students and the teacher.

Demonstration devices can be used all the way through the machine design curriculum. For kinematic studies, simple operating models of linkages, couplings or gear trains give the student an insight that is not attained from reading. Similarly, a demonstration model of a shaft vibrating or a spring surging will enhance the physical meaning of the mathematical solution.

The attempt to expand theory to explain known practice is a logical development from the use of models. For example, if a student designs a high speed cam the effects of the inertia loading may be checked by running a model of the cam and recording its followers response. Other examples include checking calculated stresses and deflections in a curved beam or a gear tooth; or the determination of a structure's behavior under dynamic loads. As the student develops experimental technique, he begins using this type of experimentation to obtain basic design data.

The next step beyond the experimental engineering study should be a special project involving analysis, design, construction and laboratory testing. These projects should continue to the point where some developmental work is necessary. If the student can be led to analyze these laboratory tests and develop an economical method of eliminating the difficulties he is improving his ability as a designer.

Research by both the students and the faculty is undoubtedly stimulated by the laboratory. It should help to put the Mechanical Engineering school on a more equal footing with the industrial research organization.

Summary

Creativeness in Design is not a new goal for teachers of design subjects. The method of achieving the goal constitutes the problem that all are attempting to solve. Before the problem can be solved, an understanding of the essential characteristics that typify the creative designer must exist. A workable picture of the learning process is of tremendous value when organizing material to be presented, both as to the order of the subject matter and as to the technique to be used in student contact. The differences between the methods herein described and those more generally in use are very likely more in emphasis than in kind. The student is introduced to a problem in the lecture, breaks it apart and analyzes it in his home study, is given in the design room a set of performance requirements for a unit involving these principles, and asked to design a unit to meet these requirements. The engineering-apprentice relationship operates while the design is worked out. The laboratory is used when indicated to determine more specific data, or to check a model of the designed unit. After this the student will request introduction to the next problem in the classroom, and the cycle repeats.

In the News

A PROGRAM FOR INTERNATIONAL UNDERSTANDING

Education for international understanding is a fundamental responsibility of all levels from elementary through adult education. Recognition of the fact that higher education bears the responsibility for leadership is evident in the fact that more than sixty national organizations cooperated in a conference on "The Role of Colleges and Universities in International Understanding" which was held under the auspices of the American Council on Education at Estes Park this summer. Since leadership in all areas of education stems from the institutions for higher education the responsibility touches every aspect and every department of these institutions. No field of teaching or research is wholly unrelated to the advancement of international understanding.

The work of the Conference centered about four main points which were of common interest to the sponsoring organizations: (1) coordination between the campus and outside agencies concerned with education for international understanding; (2) specialized training for various types of service; (3) general education on the campus and in its surrounding community; and (4) a framework for international cooperation among colleges and universities.

Nine groups worked intensively during the four days of the conference on various aspects of these major problems. They attempted to define the responsibilities of colleges and universities for international understanding and to translate the values these institutions mean to represent and to realize in world affairs into practical terms.

A Platform for Mathematics Teachers

By W. W. RANKIN

Director, Institute for Teachers of Mathematics, Duke University
Professor of Mathematics, Duke University

We, a group of mathematics teachers (high school and college) from twenty-eight states, assembled at the eighth annual session of the Institute for Teachers of Mathematics at Duke University, August, 1948, believing all persons are entitled to a fair opportunity to appreciate and to participate in the science, technology, and business which characterize our modern society, herewith present the following Platform for Mathematics Teachers.

1. We favor a more liberal policy of interchange of ideas between teachers of mathematics and those who make frequent use of mathematics.

2. We urge that teachers of mathematics:

   a. Be equipped with a well-balanced knowledge of statistics, physical sciences, advanced mathematics, and engineering techniques.
   b. Make frequent use of learning aids in the classroom, in consideration of the fact that there are many unrealized possibilities in the laboratory method of studying mathematics.
   c. Keep themselves well informed concerning the latest materials which will help them to guide students more effectively and that they acquaint guidance counselors, class advisors, and administrators with these materials.
   d. Seek, during the summer months and in vacation periods, varied experiences in business, industry, science, and government in order to obtain a clearer understanding of the applications of mathematics and to acquire the background necessary to make functional applications which will give vitality to their teaching.
   e. Give attention throughout the schools to the achievement of genuine competence in arithmetic.
   f. Have some training in work involving the principles, skills, and understanding of elementary arithmetic, because such knowledge is basic to much of the mathematics of the secondary schools.
   g. Give heed to the repeated insistence of men engaged in business, industry, science, and engineering that "arithmetic is very important, that formulas, to be useful, must be translated into arithmetic."

3. We recommend to curriculum builders in mathematics:

   a. That secondary schools provide curricula in mathematics that will challenge those students who will be leaders in science, engineering, and research, and that they also provide functional courses for the students in general.
   b. That secondary school curricular study committees for mathematics should include, in addition to mathematics teachers, representatives from the ranks of school administrators, natural and social scientists, engineers, and business men.

c. That the general practice of teaching mathematics outside the core curriculum be continued.

4. We recommend that mathematics laboratories be established in different sections of the nation and be made available to teachers and students throughout the school year and during the summer months. The laboratories might include textbooks; books on the history of mathematics, the philosophy of mathematics, the applications of mathematics, mathematical recreations and puzzles, statistics, the psychology and teaching of mathematics; films; curriculum studies; committee reports; models, instruments, machines, charts, graphs; equipment for making models, and instruments. These materials should be chosen with a view to making mathematics more meaningful, and should serve to develop mathematical concepts and principles and to relate mathematics to the fields of science, art, business, social studies, and industry.

5. We recommend the appointment of a committee of mathematics teachers and educational psychologists to study and evaluate the most worthwhile learning aids in mathematics, with recommendations as to their grade level placement and their best use.

6. We urge that school budgets include:
   a. Provision for learning aids in mathematics.
   b. Appropriations for mathematics libraries.
   c. Funds for in-service training of teachers and their attendance at institutes, workshops, and other conferences.

7. We are convinced from experience that definite benefits accrue to teachers who participate in the work of mathematics institutes. These benefits may be summarized as follows:
   a. Contact with recognized leaders in many fields of contemporary American life.
   b. Acquaintance with a wide range of source materials in mathematics such as books, reports, instruments, machines, models, and teaching devices.
   c. Participation by attending teachers in study groups working on problems which are of special interest and concern to them.
   d. Opportunities for exchange of teaching experiences in an informal and friendly atmosphere.
   e. Acquaintance with recent experiments and trends in methods of studying and teaching mathematics.
   f. Better understanding of the laboratory method of studying mathematics.

8. We endorse the appointment of a committee to work through the National Council of Teachers of Mathematics and the Mathematical Association of America to study the organization and promotion throughout the nation of mathematics institutes and workshops for teachers, to be carried on during the summer months.

9. We recommend that teachers of all subjects and at all grade levels be acquainted with the basic concepts and principles of mathematics and science.

10. We recommend that teachers seeking elementary school certification be trained in the techniques of teaching arithmetic, including the laboratory method.

11. We recommend that a joint committee of the National Council of Teachers of Mathematics, the Mathematical Association of America, and other scientific organizations be established to collect problem materials from industry, business, the natural sciences,

the social sciences, and engineering, which will be suitable for class room use. We further recommend that such problem materials be made available free of copyright to writers of textbooks.

12. We urge an active cooperation of mathematics teachers with scientific and engineering standards associations in adopting a uniform system of units of measure. Simpler systems would expedite students' progress and enliven their interest in mathematics.

13. We recommend that the U. S. Office of Education:
    a. Appoint a specialist in mathematics who would collect and make available information on the best and latest materials useful in the study of mathematics on elementary, high school, and college levels.
    b. Give consideration to the establishment of a National Mathematics Laboratory designed primarily for teachers of mathematics. This might be similar to but much larger than the regional ones recommended earlier in this platform (plank four). Such a laboratory would give much-needed encouragement and inspiration to mathematics teachers.

14. We suggest that school administrators encourage teachers to attend mathematics institutes, visit industrial plants, scientific laboratories, and to seek experiences in business and industry, in order to become more familiar with mathematics in practice and to make their classroom work more effective.

15. We urge that college and university departments of mathematics:
    a. Study the possibilities of offering a program of work leading to the Master's degree, designed primarily for teachers of mathematics.
    b. Ascertain from experienced teachers of elementary and secondary mathematics the most useful types of courses and types of in-service training needed to maintain a high degree of excellence on the part of classroom teachers.

E.C.R.C. Publications Available

The following publications of the Engineering College Research Council are available. Orders should be sent to John Weber, Secretary, E.C.R.C., State University of Iowa, Iowa City, Iowa.

"Telling the Story of Engineering Research," the proceedings of the November, 1948, meeting of the Research Council, containing remarks on how engineers may help editors and writers deal with technical subjects; 48 pages, illustrated; paper covers. Price, 35¢ to A.S.E.E. members, 50¢ to others.

Proceedings of the 1948 Annual Meeting, containing the papers presented before the E.C.R.C. at Austin, Texas; 78 pages; paper covers. Price, $1.00.

Review of Current Research and Directory of Member Institutions, listing all active research projects by titles at the 82 institutions holding membership in the Research Council; 150 pages, indexed; paper covers. Price, $1.25 to A.S.E.E. members, $1.75 to all others.

Choice of Criteria in Applying Mathematical Methods to Evaluation and Analysis of Engineering Systems[1]

By DONALD C. MAY

Bureau of Ordnance, Navy Department[2]

Foreword

In engineering and industry, many important technical decisions are made on the basis of "broad experience" and "sound judgment." The importance of experience and judgment cannot be overemphasized. However, the technical world is becoming so complicated that these decisions may prove to be expensive and inefficient unless they are backed up by considerable scientific analysis.

Such analysis often requires many separate detailed studies; but along with these detailed analyses there has been developing a type of over-all analysis or evaluation in which the separate technical results are viewed as a whole, and the interplay of the many aspects of a problem are examined. This type of study received considerable emphasis in military matters during and after the war, and has been carried out in other fields as well, often by mathematicians. Such activities are gradually spreading to various parts of the government, industry, and other enterprises as the benefits become more generally recognized. Broad features of this type of applied mathematics have been discussed previously before this society.[3]

The present discussion is limited to one special aspect of these general analytical and evaluation studies, namely, the criteria and indices which are the "yardsticks" used.

The Role of Quantitative Criteria and Indices in Mathematical Evaluation Studies

In evaluating the quality or performance of an engineering product, the purposes may be: (a) to compare alternative designs or processes in order to choose the "best" one, in a sense which must be defined; (b) to estimate the consequences of changes in design or circumstances; (c) to predict the value of a future device or process or system, particularly in terms providing some basis for deciding on whether or how to undertake new projects. One or more quantitative indices are often used in any such evaluations, along with engineering judgment.

In simple cases, a single index may provide a suitable measure of the desired characteristics. When the product or system under study is complicated or broad in scope, several indices may be required, and the element of judgment is

[1] Presented before the Mathematics Division at the Annual Meeting, Austin, Texas, June 15, 1948. The writer is indebted to R. S. Burington for constructive comments and discussion.

[2] The opinions expressed in this paper are not necessarily those of the Navy Department.

[3] "The Role of Scientific—and Mathematical—Methods in the Management of Large Scale Enterprise," Richard S. Burington, *Journal of Engineering Education*, January, 1948, Vol. 38, pp. 366–373.

also more important. When the evaluation involves future characteristics of something not yet built or developed, the judgment may be still more important. In this case, the judgment will often have to be based less on experience and more on technical predictions, so that an even greater variety of quantitative indices may be required.

For example, if an engineer were asked simply what load a certain steel cable would support, he could measure the tensile strength and give a definite answer in tons.

In a much more involved problem, if an engineer were asked which building material would be most suitable for construction of a certain highway, he would need to determine a lot of things in quantitative form, like initial cost, ease of laying, wearing quality, safety, visibility, cost of maintenance, load carried, and many others. He might then assemble numerical tables, graphs, and other data in front of him and, on the basis of experience, he could form his judgment of all of these data. Such a problem is complicated enough so that the mere compiling of numerical data would not answer the question; and, on the other hand, it is complicated enough so that judgment on the basis of experience but without a lot of additional quantitative evidence would be an unreliable guide.

If an engineer were asked to determine the best way for a city to obtain electric power, with a view to future requirements, the need for quantitative indices would be further emphasized since the engineer would be faced with additional problems involving prediction as well as all of the complexities existing in the present situation.

Whether the example be simple or complex, both judgment and analysis based on quantitative indices are needed. One without the other is almost certainly inadequate.

In making these evaluation studies, and in using the quantitative indices, powerful mathematical-physical tools are available for predicting the operation of mechanical, electrical, and other physical systems. Mathematical statistics provides techniques for organizing masses of data, for determining trends, and for estimating the reliability of the results obtained. Mathematical probability theory enables the evaluator to show the consequences of a number of uncertain factors contributing to an operation or process, and to give numerical estimates of expected successes and failures, or limits of quality, or other features of the system under study. Further, the extensive fields of analysis, geometry, and algebra can contribute to many evaluation problems.

These various mathematical disciplines, as related to evaluation studies, naturally will continue to develop as new methods appropriate for the particular problems encountered are investigated. However, from the standpoint of most practical evaluation work, the basic mathematical tools are available, and in generous variety. The real problem usually is where to apply them, how to fit them to the problem at hand, or what to measure, in order to answer a complicated question. How should indices be selected, and how should the information they provide be interpreted?

Properties Desirable in Any One Index

Relative and absolute indices. An index or measure may be used to compare one item or method or process with another with several different degrees of definiteness. For example, if three engine designs are being compared with each other from the standpoint of torque at 1000 r.p.m., it would be possible to conclude that: (a) the torque of engine A is greater than that of B, which in turn is greater than that of C; or (b) the torques of engines A, B, C are in the ratio 10:8:3; or (c) the torques are 100 foot-pounds for A, 80 foot-pounds for B, and 30 foot-pounds for C. The last of these conclusions, in absolute terms, would presumably be the most useful, but

also harder to arrive at than the first two conclusions which are in relative terms.

Relative comparisons are often important for showing trends. Relative comparisons are also particularly suited to complicated problems where factors contributing to a numerical estimate are uncertain, where a number of outright assumptions must be made in order to arrive at the comparison, or where there are several different procedures for analysis.

In many cases approximately the same uncertainties are associated with all of the items being compared, so that by giving a relative comparison the uncertainties partially disappear. For example, in some types of tests carried out with models it might appear that process A is twice as fast as process B, and there might be good reason to expect that this same relation would hold for the full scale equipment. At the same time there might be the most serious doubts as to the scaling laws which would enable the full scale speeds of operation to be predicted from the models, so that by sticking to the relative comparison a more reliable evaluation will be obtained.

In the same manner, use of relative instead of absolute indices may cancel out or minimize the differences between various analytical systems or procedures of evaluation which might be used with the same data.

Choice of units and form. The same basic quantity can often be given in several different units or forms of expression. In this respect, the difference between, say, miles per hour and hours per mile, or other trivial variations, is not significant, except that one type of expression may be more familiar than another and hence give a more easily grasped impression of the measurements being discussed. But there are cases where various expressions of the same basic quantity may differ more importantly.

As an illustration, suppose that automatic fire extinguishers are being designed for a room containing electrical switchboards, and suppose that the effectiveness of the equipment is measured in two alternative ways. First, let P be the probability that a fire will be extinguished before more than one panel of the switchboard is destroyed. Second, let N be the number of fires which can occur, on the average, before more than one panel is destroyed. Either P or N might be a plausible measure of the effectiveness of the fire extinguisher system, and of course they really are a measure of the same thing. An increase in either P or N represents an increase in fire protection. The relation between them is $N = 1/(1 - P)$, and if $P = 0.9$ for example, then $N = 10$. Now, if a different equipment were considered, P might drop to 0.45, whereupon it appears that the second system is "half as good." But the value of N for the second system turns out to be about 1.8, so that from this standpoint the second system appears to be about "one-sixth as good." Since both indices P and N represent the same aspect of the same problem, clearly some caution is needed in interpreting them to compare the two systems. This type of difficulty is sometimes rather subtle and easily overlooked, but very important.

Differential properties. A measure or index may be of less interest for showing the magnitude of some characteristic than for showing the influence of changes in the situation. That is, the differential properties of the index may be important.

As one aspect of this, it is desirable to choose an index with the proper sensitivity to the principal variables. There is no object in having an index so insensitive that it makes completely different processes or devices appear the same when they really are not. On the other hand, if an index is too sensitive to the assumed conditions, then a variation in the value of an index, as between, say two possible processes, may not reflect an important difference in the processes, but merely a minor peculiarity in the par-

ticular numerical data used in computing the indices.

To illustrate a sensitive and insensitive index, one may consider the remote possibility that a radio station will go off the air temporarily due to mechanical failure. One index of station performance might be the probability that the station can function for a month without failure. Suppose this probability is 95% for a certain type of equipment. All sorts of improvements might be made in the equipment, and this probability might rise only to 98%. Clearly, this percentage would not be sufficiently sensitive to the state of the equipment for it to be the best measure of the value of the improvements. On the other hand, the number of minutes of failure per month might reflect quite adequately the consequences of changes in the equipment.

Often the assumed values used in computing an index are not known precisely, either because experimental data are inexact or inadequate, because unknown future conditions must be estimated, or because at some point an intelligent guess must be made. It is clearly desirable that these errors in the basic assumptions should not cause undue errors in the final index.

Likewise, in any calculation of an index wherein it is necessary to fix certain parameters and thus consider a particular "case," it is important to determine whether the result obtained depends critically on the particular case considered.

Number of variable parameters. Criteria or indices must not be too simple or too inclusive. If too simple, they will not properly take account of many factors. If too complex, they will lump together too many things, and thus not disclose important trends and factors. In particular, it is usually desirable that values of an index be computed for sets of parameters in which only one or a small number of the parameters are varied.

Boundary conditions. In determining the dependence of an index on a number of parameters, it will often be necessary to take account of boundary conditions connecting the parameters. This will be particularly important in any "optimizing" process in which an attempt is made to maximize an index by selecting the most favorable values for the parameters.

Selection and Presentation of a Set of Indices

Completeness. In general, a complicated problem has a number of different aspects which must properly be taken into account, and no single simple quantity can give the whole picture by itself. Even if it is agreed what properties any one index should have, there remains the important problem of making sure that every important factor is considered, and then adequately combining them all as a basis for a judgment or decision.

Unfortunately there is no purely formal way to make sure that some important feature has not been neglected. This is a place for practical skill and for knowledge of a field, rather than mere technical fluency with formulas or data. The mathematician as such must be particularly careful not to make purely formal and theoretical estimates of the situation he is analyzing.

The mathematician must have the advice of others familiar with design, manufacture, economic features, special physical details, use or operation, and all other pertinent information. In obtaining such help, the mathematician must maintain a broad view since the specialists' preoccupation with gadets or with inventing short cuts or better methods may tend to emphasize some particular aspect of the problem which may be very challenging, but which may not in itself give a balanced picture of the whole problem in terms of the final goal to be reached.

In addition to obtaining widespread advice, particularly in the early stages of a study, the analyst should generally make note of every parameter which appears to affect the final product. In

many cases, some indication of the accuracy, reliability, or spread in these quantities is also significant. This list will depend partly on the physics of the situation and partly on additional practical features brought out by advice of others or by the invaluable element of experience. The indices selected must then take account of all of these parameters which are important, possibly in groups related to one another. It is recognized, of course, that it may not be sensible to try to put *every* factor in the form of quantitative indices; it is merely desirable that every factor be given some consideration.

Amount of detail. In general, the most difficult problem is to be sure that all significant factors are allowed for. In practice, of course, the number of items considered must not be too great either, or the multiplicity of details will obscure the main results to be obtained. An analysis may often disclose which parameters really are important. However, even to make the analysis, some selection must be made; many a mathematical evaluation study has become bogged down because someone knew about a great many detailed factors and tried to put them all in a formula, unsuccessfully, rather than grouping some of them or ignoring some of them, in order to get the broad trends. It is always important not to over-analyze, over-evaluate, or over-use mathematical methods.

Groups of dependent indices. The various indices applicable to one problem can be subdivided into groups of dependent quantities, the separate groups being more or less independent. In considering, for example, an automobile design, there could be a number of related indices pertaining to the engine and driving mechanisms, another group pertaining to the springs or suspensions, another group pertaining to paints and coatings, and so on. In the engine group, the parameters might be closely related so that, say, an increase in power would have direct consequences in weight, and in type of bearings. The selection of a particular design would represent a balance between many interacting tendencies. Presumably these would have nothing directly to do with the paints and coatings. All of the independent groups may of course be somewhat related by cost, or by the fact that the whole product must be suitable for some particular ultimate purpose.

Simultaneous representation of many indices. It may sometimes be useful to consider some way to present many indices at once, as by an N-dimensional graph. The individual criteria or indices may be considered somewhat analogous to coordinates in a spatial coordinate system.

The concept of an all-inclusive graph is closely related to the idea of a "master index." When several indices for a given product or process have been determined, such as cost, speed of operation, total output, life expectancy, ability to meet adverse circumstances, adaptability, accuracy or freedom from failure, and so on, there may be a temptation to estimate the relative importance of each of these indices, and then by some kind of weighting factors to combine them into a single master index. This combining of indices into a single index is probably intended to be a parallel of the process of judgment which would put all the factors together with a feeling for the important and unimportant characteristics.

Some caution is needed here. However inclusive an index is believed to be, it may not tell the whole story, and generally should not claim to do so. The technical man who wants to help put judgments on a sound basis would probably do well not to try to eliminate the judgment but merely to provide some quantitative guides for it. But even if the various quantitative indices *do* take account of most or all of the important aspects of a problem, there is still some danger in weighting and combining them, since in many cases there really is no one best answer, but a lot of answers

depending on a lot of conditions. An attempt to summarize all of these results in a single number may be useless and misleading.

These analytical procedures for putting many indices together must therefore be used with caution, if at all. However, they may provide a conceptual framework which will aid in attacking the whole problem.

Some more practical procedures are available for aiding in drawing up the "balance sheet" of the many factors. Perhaps the most elementary, but most important step is to present as many factors as possible in a convenient, brief form which allows them all to be seen at once in their relations to each other. Tables and graphs can often be prepared to do this. Matrix representation of many quantities is also sometimes useful. The manner of presentation is of the greatest importance, and may warrant considerable effort.

Interpretation of a Set of Indices

It is evident that complicated problems may lead to many and complicated indices. This complexity is not an indication that the analysis is deficient, but merely a reflection of the multiplicity of factors which must usually be considered. When all of the indices are computed, classified, and presented in convenient form for ready comparison, how can their over-all implications be determined?

Balancing gains and losses. Perhaps the most important feature of most of these technical decisions is the compromise involved. Most engineering designs or decisions represent a selection, or compromise among a great many possibilities, with an attempt to balance gains in one respect with losses in another. When possible, this balancing is done so as to maximize the over-all performance in some sense.

The meaning to be attached to maximum over-all performance is itself not always obvious and easily determined. According to one point of view or one quality (or one index), one device may appear better than another, whereas another point of view will show quite a different device to be better. Uncertainties in data or other statistical variations may also make one device appear better than another without true significance. These difficulties cannot be resolved merely by further study of the indices as such, but require a deeper insight into what the real problem is, or what is really wanted of the final product.

Likewise, while a particular device may be "best" among all practical possibilities for some particular circumstances, this device may not be as good as others when the circumstances are changed. The compromise device which will be fair for a broad class of situations may be more desirable than the device which will be excellent in some limited situation.

In these and other respects it is clear that the balance among factors which is desired depends not only on the factors but on the desired quality to be optimized. The study of many indices and many cases may disclose trends which will help show what should be optimized. This may be a large contribution of the analysis.

Economic analogies. The balancing of gains and losses from various sources, the choice between several possibilities, the determination of what may be obtained at what "price" in the broad sense, and the interplay of competing factors provide an evident analogy with problems in economics. Indeed, in a sense, the problems involved often are a type of economics with an engineering setting. As such, some of the apparatus of economic theory, particularly mathematical economics, are pertinent. This is true even though the engineer may not naturally use the terminology of marginal utility, price, value, demand, and the like. Quite elaborate theories are available which goes far beyond the elementary applications of these terms.

Determining important factors. Another important aspect of balancing different factors is the determination of

the relative importance of the various parameters and developments. This problem can sometimes be examined in connection with a standard deviation S of some quantity, such as an error in performance, which arises from a number of component errors: $S^2 = S_1^2 + S_2^2 + S_3^2 + \ldots$. If it is desired to minimize S, clearly it is desirable to reduce all the S_i's. However, if one or more of the S_i's are appreciably larger than the rest, then the principal effort should be put on reducing these large S_i's. Reduction of those which are already small would contribute very little to reduction of the total S.

Indices are not always combined by so simple a method as adding squares, but in any case it is important to determine which factors have the overriding influence on the final quality, and to indicate thereby what improvements or developments are of prime importance, which are the bottlenecks, and which are unimportant.

Consideration of some but not all known factors. Many times it will not be possible to take account of some known factor, for lack of data or because of the complexity of the situation. Then it may be desirable to optimize the device with respect to those factors which can be handled analytically (noting clearly what factors have not been considered), and leaving the final decisions to other authorities who can contribute skilled judgment and experience in putting the whole picture together.

When some of the factors cannot be explicitly included in the analysis, the analyst can often help by indicating a number of possible solutions which might be considered under various conditions. That is, the analyst can say that System A will have some particular characteristics, System B will have other stated characteristics, and so on with C, D, ... The final decision can then consist of picking out that system which most nearly fits in with the whole complex of factors.

Conclusion

Development projects are now often so complex that it is essential to proceed at least approximately toward a known goal, and expend every effort to end up with a balanced system which will meet stated requirements. This process can be aided by an over-all evaluation which attempts to determine the possibilities and to put all the factors in proper perspective. A principal tool of the evaluator is the quantitative index or criterion. His contribution is to present, at various times during the development, a balanced picture of what is needed and what to expect in terms of these indices.

The use of these quantitative indices is of course pertinent to the work of the engineer, designer, inventor, and all others who have a hand in developments, as well as to the studies of the evaluator. However, it is the unique responsibility of the evaluator to look at the whole picture and to put together the information which each separate technical expert can provide on different phases of the general investigation. It is therefore his responsibility also to choose and use indices and criteria best suited to his broad studies.

ANNUAL MEETING
University of Washington
Seattle, Washington, June 19-23, 1950

Minutes of Executive Board Meeting

American Society for Engineering Education

NEW YORK CITY

SEPTEMBER 15, 1949

A meeting of the Executive Board of The American Society for Engineering Education was held on Thursday, September 15, 1949, in the Engineering Societies Building, New York City. Those present were: Thorndike Saville, President, H. H. Armsby, F. M. Dawson, B. J. Robertson, F. E. Terman, J. S. Thompson, A. B. Bronwell, J. I. Mattill (guest), and D. Daum.

Report of Secretary

1. The Secretary reported that the revised teaching manual had been submitted by Dean Norris, Chairman of the Committee, to Mr. Wight of McGraw-Hill Book Company and had been accepted for publication. The Board voted to approve publication of the teaching manual as now submitted to McGraw-Hill Book Company under the terms set forth in the minutes of the General Council meeting of November 8, 1948, with the added provision that the Society reserves the right to determine whether or not it should participate in any future revisions of the manual or to withdraw from participation in the publication of the manual if it so desires. It was requested that the Secretary inform both the author and publisher of this action by the Board.

2. The Secretary reported that Mr. E. C. Koerper, Chairman of the Committee on Relations with Industry, had proposed a plan whereby he and his associates would subsidize personally the cost of publishing the manual "Speaking Can Be Easy" with the ASEE and ECPD to handle the distribution and sale of copies of the manual. This plan would eliminate the necessity of either society subsidizing the initial cost of publication of the manual. The Board voted that the Secretary be authorized to proceed with negotiations with Mr. Koerper and his Committee on this basis.

3. The Secretary announced that Dean R. C. Ernst, Chairman of the Southeastern Section, had reported that the research grant (which expired June 1, 1949) made to the Southeastern Section by the General Education Board had been renewed for another two years.

4. The Secretary reported that the proposed constitutional amendments had been submitted to the entire membership for ballot.

5. The Secretary submitted estimates obtained from the printer regarding the adoption of a new format for the Yearbook issue of the JOURNAL. This proposed change would not result in any saving during the current year but would effect a saving of $700 in future issues of the Yearbook. The Board voted to adopt the new format.

6. The Secretary reported that the membership drive was off to a good start, that chairmen had been appointed for each of the states and that publication was underway of the descriptive pamphlet on Society activities entitled "Dynamic Influence in Engineering Education." It was the opinion of the Board that since this booklet had been mailed to

all individual members of the Society last year, it would not be necessary to mail it to present individual members of the Society this year. The booklet will, however, be distributed to all members of the Membership Committee and to those whose names are submitted as prospective members.

7. Arrangements for the Kansas City meetings of the ECAC, ECRC, and General Council were discussed.

Report of Treasurer

1. The Treasurer submitted a report of receipts and disbursements for the period July 1 to September 13 of the current fiscal year Since the duties of the Secretary and Treasurer are very generally stated in the Constitution and By-Laws of the Society, he recommended, and the Board voted to continue, the routine procedure which has been in effect for recent years as follows:

a. The Treasurer co-signs checks and vouchers, examines all monthly bank statements and the final audit, and is official advisor to the Executive Board in all financial matters.

b. The Secretary is responsible for all properties of the Society, including the bonds, which are now in the vaults of the State Bank and Trust Company, Evanston, Illinois.

c. The Secretary receives, accounts for, and disburses the funds of the Society; submits quarterly statements; and, in cooperation with the President and Treasurer, prepares a proposed annual budget for consideration of the Executive Board and General Council.

d. The Secretary is responsible for having the books audited annually. For the past two years, this has been done by Professor E. C. Davies, CPA and Head of the Accounting Department of Northwestern University.

e. The Secretary and Treasurer of the Society are bonded in the amount of $10,000 each.

The Board instructed the Secretary and Treasurer to prepare an appropriate statement of the duties of their offices to be submitted to the Board for consideration at its next meeting and possible inclusion in future revisions of the Constitution and By-Laws.

2. The Treasurer announced the purchase of $10,000 in U. S. Government Bonds as authorized by the Board at its meeting on June 20, 1949.

Report of the Vice President in Charge of Divisions and Committees

Vice President Robertson reported that he is planning to write several letters to the Divisions and Committees during the current year. The first of these letters, outlining the duties of Division officers and informing them of their budget allotments for the year, has already been distributed. Vice President Robertson indicated that another letter will be distributed soon covering items acted upon by the Board at this meeting which affect Divisions and Committees.

Report of Vice President in Charge of Sections and Branches

Vice President Armsby reported that the Committee on Sections and Branches has been reorganized, and is now composed of the members of the General Council representing Sections. It was felt that this would give the Sections a closer relationship to the activities of the Society, since it would insure larger representation of the Sections at meetings of the Committee, and would result in one man being responsible for reporting to each Section on actions taken by the Society.

Vice President Armsby reported that he is also following up requests of various schools regarding the formation of branches at their institutions, and will report on results at the next meeting of the Board.

He suggested that the Section meetings are the logical place to encourage activity on the part of the younger members of the Society, and the Sections

should be encouraged to seek out younger men for participation in their programs.

The Vice President also reported that his Committee is commencing work on the preparation of a Sections manual as proposed by the Executive Board at a previous meeting.

Enrollment Statistics

Samples were distributed to the Executive Board of the forms which will be used this year in collecting the enrollment statistics under the joint sponsorship of the ASEE and the U. S. Office of Education. The Board agreed that the Society would publish breakdown figures on these statistics for only those schools having one or more curricula accredited by the ECPD, and only totals will be included as collected for other engineering schools listed in the U. S. Office of Education list. It was voted that the Secretary should attempt to determine the method of accreditation of Canadian schools for use in selecting those Canadian schools to be included in the ASEE listing.

Report of ECRC

Vice President Dawson submitted a report of the ECRC giving names of new Committee members for the coming year and outlining their proposed panel discussion program for the coming meeting in Kansas City.

The Vice President announced that the ECRC proposes to publish a brochure entitled "The Quest for the Best" presenting case history results of fundamental research conducted in universities and colleges. This proposed publication was approved by the Board.

Vice President Dawson also announced that the work of indexing the 1949 Review of Current Research had been completed and that copies of this Review would be distributed in about ten days.

At the suggestion of President Saville, Vice President Dawson will prepare a statement of the major objectives of the ECRC for the guidance of the ECRC Executive Committee and the Executive Board.

Committee on Census

President Saville announced the appointment of a temporary committee, under the Chairmanship of Vice President Armsby, on collaboration with the Census Bureau. The Board approved the action of this Committee previously taken and recommended that President Saville write a letter to the Bureau of the Census endorsing the report of this Committee and the recommendations they had made.

Committee on Teaching Aids

Copies were distributed to the Board of the report of the Committee on Teaching Aids, prepared by Professor W. J. King, Past Chairman. Professor Carl W. Muhlenbruch has been appointed new Chairman of this Committee. The immediate objective of this Committee is to appoint subcommittees to review, evaluate, and accredit the visual aids presently available and to encourage the companies manufacturing visual aids to consult with the reviewing committees and pay expenses involved. The reviewing committees will then prepare a report on the use and value of the various visual aids. This report will be put in bulletin form and will be distributed by the Society to the engineering colleges.

Committee on Improvement of Teaching

A steering committee for the Committee on Improvement of Teaching, under the Chairmanship of Professor B. R. Teare, Jr., has been appointed. The steering committee will formulate a statement of the problem and a proposed method of approach. The steering committee will then be replaced by a full committee which will complete the study and prepare a report for submission to the General Council.

Annual Meeting

1. President Saville submitted a proposal regarding the procedure for nomi-

nation and election of officers at the annual meeting. The Executive Board recommended that this procedure be submitted to the General Council for approval: (*a*) A preliminary canvass of possible candidates would be made by the new Nominating Committee after the elections at each annual meeting. (*b*) Nomination ballots would be published in the December and January issues of the JOURNAL with prominently displayed notice to members to return them. (*c*) An informal ballot by letter would be taken by the Nominating Committee in March or April. This will be followed by a second informal ballot in April or May. (*d*) The Nominating Committee would meet on Monday afternoon at the Annual Meeting for the purpose of making the final nominations. (*e*) The report of the Nominating Committee would be presented and election of officers would be held at the Wednesday morning General Session.

This plan would encourage nominations from the Society membership, would enable the entire Nominating Committee to participate in nominating procedure, and would facilitate a meeting of the newly elected officers and retiring officers during the annual meeting of the Society.

It was also suggested that the Vice President in charge of Divisions suggest to the Division Chairmen that they elect officers prior to the Wednesday General Session so that the new and retiring Division officers could discuss plans for the succeeding year.

2. To minimize the conflicts of conferences having similar interests at the annual meeting, the Board voted that the ECAC and ECRC meetings would be considered as conferences, and that meetings of Committees and Divisions with non-conflicting interests would be scheduled at the same time as the meetings of the two Councils.

3. The Board approved a plan providing for two general sessions to be held on Wednesday morning and afternoon and a banquet on Thursday evening. The Research and Administrative Councils will hold their principal meetings on Tuesday morning and Thursday morning, respectively, concurrently with other conferences which have non-conflicting interests. Registration will be on Monday morning, June 19, and conferences will be concluded on Friday noon.

4. The Board voted that the February first deadline for submission of program material by the Divisions and Committees be continued in order to make it possible to complete the scheduling of conferences, luncheons, dinners, etc., with the host institution and get the preliminary program printed and in the mailed by the end of April.

Report of the ECAC

Vice President Terman announced the details of the ECAC program for the Kansas City meeting. The theme for their program is "Atomic Developments Present Engineering Education with New Problems."

Vice President Terman reviewed the present Committees of the ECAC. It was suggested that the ECAC might make studies of methods of faculty evaluation, teaching loads in engineering colleges, and other administrative problems. It has also been suggested that a new investigation of engineering education, similar to the 1923–28 report might be undertaken at this time.

Society Committees

President Saville made a number of recommendations intended to simplify and correlate the Committee structure of the Society. The following are actions taken by the Executive Board:

1. The Board voted to establish a Coordinating Committee on Relations with Government, this Committee to be composed of representatives from all of the Society committees that participate in

government relations and whatever other members the President of the Society may desire to add. The Coordinating Committee will correlate the activities of the individual committees and investigate areas of relationships with government which are not handled by existing committees.

2. The Board voted to discontinue the Committees on Professional Development, Functions of the Vice Presidents, and Teaching Manual.

3. The Board voted that our representation on the Committee on Status and Deferment of Engineers be discontinued and that this subject be referred to the Administrative Council.

4. It was suggested that the Research Council set up a Committee on Graduate Studies which would coordinate its activities with those of the Division of Graduate Studies. The Vice President in charge of Divisions and Committees was asked to suggest to the Chairman of the Division of Graduate Studies that the chairman of the new committee under the ECRC be appointed a member of the Executive Committee of the Division of Graduate Studies.

5. The Secretary presented the recommendation of the Committee on Relations with Industry that a committee of the Society be appointed to study the problem of financing of higher education. Vice President Armsby pointed out that a similar committee had been appointed by the Association of American Colleges which had been given a substantial subsidy to study this problem. The Executive Board appointed President Saville and Vice President Armsby to investigate this matter with the recommendation that a prominent member of the Society be appointed to work with the committee of the Association of American Colleges.

6. The Secretary presented the Report of the Interim Committee for Young Engineering Teachers. This report outlined the objectives of the Committee, the activities in which the Committee might engage, and the topics which might be of pertinent interest to young engineering teachers. The report was referred to the General Council with the following recommendations:

(*a*) A conference of young engineering teachers be held at the annual meeting, the program to be arranged by the Committee.

(*b*) Approval of the recommendation of the Committee that the activities of this new group be brought to the attention of administrative officers in engineering colleges.

(*c*) These activities to be continued on a committee basis, the Interim Committee making recommendations as soon as possible to the President for additional members of thhe Committee. The Interim Committee should continue to serve throughout the year, and those members of the Committee who are over the age limit recommended by the Committee can be replaced by new appointments at the end of the year.

(*d*) That Professor Schwartz, Chairman of the Committee, prepare a short article on the activities of this Committee for publication in the JOURNAL.

UNESCO

President Saville reported on his attempts to have the Society included as a permanent institutional representative on UNESCO instead of on a rotating basis. He will continue to seek permanent representation.

The Board recommended that Vice President Armsby serve as liaison representative of the Society to cooperate with Mr. Green of the Department of Commerce in legislative matters dealing with engineering education in President Truman's Point 4 program.

James H. McGraw Technical Institute Award

The Executive Board approved the resolution submitted by the Technical

Institute Division to announce the name of the recipient of the James H. McGraw, Sr., Award in Technical Institute Education at the annual banquet.

Dues

The Board recommended to the General Council that the $5.50 and $6.00 dues status as listed in the Constitution and By-Laws apply only when a member's full-time services are related to the activities of educational institutions.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

Candid Comments

A SLUG AT THE SLUGGERS

If the recent article by Professor R. C. Binder "The Case for the Sluggers" (JOURNAL OF ENGINEERING EDUCATION, June 1949) were to be delivered to a class of students, we can well imagine that the following discussion would take place:

Prof.: Are there any questions on the use of the slug in engineering?

Student: When I go to the store and buy butter, they sell it by the pound and not by the slug. Why is that?

Prof.: Unfortunately, the pound mass is the legal unit of mass in the United States.

Student: But Professor, when I go into your laboratory and use your platform scales or your precision balance, the answer is also given in pounds mass.

Prof.: Ah———, yes, these instruments all measure *mass* and are calibrated to read in pound mass units (and this calibration is independent of the local acceleration of gravity).

Student: Do we have in the laboratory an instrument to measure weight (i.e., gravitational pull)?

Prof.: Errr, I think I have an old spring scale that could be used, but it is not very accurate.

Student: Then this w that you are talking about we have no way of measuring in the laboratory?

Prof.: Ye . . . sss, we can measure the mass in pounds on our balances and then divide by 32.1739 and then multiply by the local acceleration of gravity, g.

Student: And, to get the mass in slugs, you divide this weight by g, is that it?

Prof.: Exactly.

Student: Well, it seems to me that all we are doing is using the pound mass in all our measurements and reasonings and then dividing by a fixed number 32.1739 which is not the acceleration of gravity but merely shows that the slug unit of mass is 32.1739 times the mass unit. Moreover, since you do not measure weight in any of your laboratory measuring devices, I do not see why you insist on showing it in your calculations in the form, w/g.

E. F. OBERT,
W. H. ROBERTS,
J. F. BAILEY,
G. M. BROWN,
Northwestern University.

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* Comments on articles appearing in the JOURNAL or other items of current interest to engineering educators will be published in CANDID COMMENTS. Contributions should be sent to the Secretary. They should not exceed 500 words and may be edited where necessary.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	Spring, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 13, 1950	D. S. Clark, Purdue University
Middle Atlantic	Columbia University	Dec. 3, 1949	R. T. Weil, Jr., Manhattan College
National Capital Area	Washington, D. C.	Oct. 4, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Rochester	Nov. 18–19 1949	H. W. Bibber, Union College

ANNUAL MEETING of the A.S.E.E.

June 19-23, 1950

at

THE UNIVERSITY of WASHINGTON

Seattle, Washington

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JERGER, EDWARD W., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. G. Murphy, H. J. Stoever.

JONES, WILLIAM P., Supervisor, Education and Training, Carnegie-Illinois Steel Corp., Pittsburgh, Pa. B. R. Teare, Jr., D. W. Ver Planck.

JURY, STANLEY H., Assistant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tenn. R. M. Boarts, H. J. Garber.

KINTIS, DINO H., Associate Professor of Aeronautical Engineering, Tri State College, Angola, Ind. Q. J. Hawthorne, C. E. Shaw.

KOPKA, MERLAND A., Counselor, Graduate Placement, Wayne University, Detroit, Mich. A. R. Carr, S. F. Hicks.

MANNUCCIA, HERBERT, Special Lecturer, Catholic University, Washington, D. C. K. K. Murcichian, P. H. Robbins.

MASSARI, SILVIO C., Technical Director, American Foundrymen's Society, Chicago, Ill. A. B. Bronwell, Thorndike Saville.

NUTT, GEORGE B., Head, Agricultural Engineering, The Clemson Agricultural College, Clemson, S. C. H. E. Glenn, D. D. Curtis.

OPPENHEIMER, FRANK, President, Gramercy Import Co., Inc., New York, N. Y. E. G. Pare, H. C. Spencer.

PARDUE, LOUIS A., Professor of Physics, and Dean of Graduate School, University of Kentucky, Lexington, Ky. D. V. Terrell, A. L. Chambers.

PENCE, RAYMOND V., Professor of English, University of Notre Dame, Notre Dame, Ind. R. J. Schubmehl, W. L. Shilts.

PERRY, RAYMOND J., Professor of Chemistry, U. S. Coast Guard Academy, New London, Conn. G. A. Tyler, E. P. Rivard.

PRATT, HUGH S., Assistant Manager, College Department, Ronald Press Company, New York, N. Y. G. W. Farnham, Nell McKenry.

PRINGLE, ORAN A., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. R. L. Scorah, P. Ogden.

RAMSEY, ROBERT D., Instructor in Civil Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. J. M. Henderson, D. W. Mattson.

RAY, MILLARD L., Director, School of Engineering, University of Houston, Houston, Tex. D. C. Fabel, S. M. Spears.

ROSENTHAL, PHILIP C., Associate Professor of Min. and Met., University of Wisconsin, Madison, Wis. D. J. Mack, G. J. Barker.

SALTMARSH, VIOLA, Director of Placement, Tufts College, Medford, Mass. K. B. McEachron, C. J. Freund.

SOELLNER, ROY O., Administrative Staff, Electronic Engineers, Central Radio and Television Schools, Kansas City, Mo. G. Dobbins, R. H. Crawford.

STONE, LOUIS N., Assistant Professor of Electrical Engineering, Oregon State College, Corvallis, Ore. B. H. Nichols, P. C. Magnusson.

VAN ZEELAND, FRED J., Director, College of Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. S. A. Eng, C. O. Werwath.

WOOD, WILLIAM E., Assistant Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. B. Morrill, W. E. Reaser.

37 Applicants this list.
112 Previously elected.
149 New members elected this year.

Editorial—Counselling Engineering Students

By HENRY H. ARMSBY

Vice President of the Society and Specialist in Engineering Education, U. S. Office of Education

The situation in which the engineering colleges find themselves at the present time calls for greater attention to programs of guidance and counselling than they have received from engineering educators in the past. A.S.E.E. might well take the lead in this important activity, especially in the Sections and Branches, which are closer to the problem than is the National Society.

It seems evident that for at least some years to come engineering graduates will face much keener competition than has been the case in recent years, and they may even be seeking admission to an overcrowded profession. Fairness to our students, present and future, demands that they be adequately informed as to the requirements of the engineering profession, and the employment opportunities in it. They should also be advised of the factors tending to increase the nation's needs for well-trained engineers, which were discussed in the report of the A.S.E.E. Manpower Committee, and of the great demands and opportunities for graduates of good technical institute courses, which have been pointed out in numerous surveys and reports. They should be further advised of the well known fact that engineering education has great value as general education and forms a good foundation for work in many professions other than engineering.

In view of this latter fact, it is improbable that engineering schools in general will impose rigid limitations on enrollments in accordance with local or national needs for graduate engineers. However, it is highly important that they make every effort to insure that the education they give their students shall be as effective as possible, by making certain that they are devoting their energies and their funds to those students who can best profit from them.

Every effort should be made to identify through aptitude and achievement testing programs in the high schools those students who have the aptitudes and abilities which will qualify them to be successful engineers and scientists, and also to identify those who would profit more by a good technical institute training than by attempting a four-year college course in engineering or science. This should be done early enough in the high school course to give students an opportunity to adjust their high school courses to their future plans. Efforts should be made to encourage the well-qualified students to continue their education beyond high school, and should be accompanied by some form of help for those who need help, financial or otherwise, to achieve their ends.

This program will call for close cooperation of the engineering schools with each other and with high school authorities, such as has been the objective of the A.S.E.E. Committee on Secondary Schools ever since its establishment. Probably the program can best be promoted by visits to high schools by representatives of the engineering colleges and the engineering profession, provided the activities of these visitors are

directed toward genuine guidance rather than propaganda for individual institutions.

The college admission process should include an adequate testing program, such as has been advocated by the E.C.P.D. Committee on Selection and Guidance, a program sufficiently comprehensive to insure that those students actually admitted are well qualified to profit by the work of an engineering school. After admission to college a well thought out counseling program should be in effect to determine which students are most likely to succeed in the various functional divisions of engineering such as construction, research, design, teaching, etc. Consistent efforts should be made to furnish opportunities for students to confer with practicing engineers, research workers, teachers, etc., as additional means of guiding each student into the work for which he is best adapted. If possible, curricula should be modified to fit the needs of these various groups and at least those students qualified for research and teaching should be encouraged in every possible way to continue their education beyond the bachelor's degree.

The counselling program should not be limited merely to vocational guidance, but should also include counselling on psychological, emotional, and social problems, which are experienced not only by the maladjusted, but to some extent by all students. Scholastic failures are often due to unsolved social problems or to emotional upsets rather than to mental or physical disability. Students must learn that we have to live with differences—differences in religion, in cultural background, in economic and political backgrounds—and that we must learn to cooperate with those whom we do not like as well as with those whom we do like.

Engineering teachers can make valuable contributions to all the phases of counselling mentioned above. In fact, counselling should not and cannot be confined to the Office of an official counsellor, but is constantly going on through the students' person-to-person relationships at home, on the campus, and in the classroom, and every teacher is, consciously or unconsciously, a counsellor for his students.

There is need for all engineering teachers to appreciate the value to the students and to society of a well rounded program of counselling, and their own important part in it.

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

Seattle, Wash. **June 19–23, 1950**

Pre-College-Entrance Orientation in Engineering

By L. E. GRINTER

Research Professor of Civil Engineering and Mechanics,
Illinois Institute of Technology

Synopsis

It is here suggested that the period between acceptance of a student into a college of engineering and his final registration therein be used on a part-time basis as a period for certain orientation readings and refresher studies. A week or more of this period, which is commonly at least two months in length, could be taken over by the engineering college either for required reading resulting in a formal report or for informal recommended reading and study. No equivalent amount of time seems available in the freshman year.

Orientation and Refresher Courses

Over the past two decades orientation programs for freshman engineers have developed and waned in sympathy with other pressures that have grown up within the borders of our engineering curricula. No doubt the great pressure for growth of the humanistic-social stem of the curriculum has had its influence in reducing formal orientation courses in the freshman year. Whether the orientation plan of a given institution involves inspirational lectures, assigned readings or problem work, time must be used to make the plan successful. The arrangement of two or three days at registration for a few lectures and an inspection of the Campus has its merit in orienting the student to his new environment, but it serves only a minor function in broadening his useful knowledge of the engineering profession.

A related activity that finds little attention within the formal curriculum of the freshman year is a planned refresher of critical high school studies. When veterans began to return in 1945 there was great emphasis immediately upon refresher courses. It was the common observation that veterans profited by such studies, and no doubt many were thus saved from early failure in regular courses. As the veterans began to be replaced with recent high school graduates, refresher courses disappeared. However, it seems probable that the lower one-third of present freshmen need refresher work fully as much as the veterans of 1945. The percentage of failures in mathematics, chemistry, physics and mechanics during the freshman and sophomore years testifies forcefully to inadequate preparation.

Within the present framework of four-year curricula little is likely to be done about formal orientation or refresher courses. Students who are obviously deficient in mathematics are often given additional hours of instructor contact for the standard credit in freshman mathematics, but the average student starts his study of college algebra after a two-year lapse of mathematical thinking. It is easily observed that incapacity to make the transition from high school to college during the first six weeks results in a frustration that is never overcome by many students. The result is probably unnecessary failures and an increased percentage of students who develop a "get-by" attitude.

Before the war relatively few of our institutions accepted their students before early fall. Now it has become common to require applications in the spring or early summer. No doubt there will be some retrogression in this regard as applications reduce, but procedures once established tend to maintain themselves. Hence, for large numbers of students admitted to our engineering colleges a period of two to four months will continue to occur between admission and final registration. This then is the only free period available for orientation and refresher reading and study. As yet we have made no formal attempt to capitalize upon the use of this time.

Pre-College-Entrance Reading

The question proposed is whether the period of collegiate influence upon the student might not be moved backward to the date of college acceptance by suggested or even required readings of an orientation and refresher nature. Could not the study of a single book or even a few selected chapters be made to provide a useful transition into the engineering collegiate world? It is of no moment that the ideal text may not be available for immediate adoption. Several useful books do exist, and others will quickly appear as soon as a demand for their use becomes evident. Some institutions might wish to provide without charge mimeographed notes with suggested orientation readings readily available in any library and with problems to test the student's need for refresher studies in suggested textbooks.

A general outline of reading or study that the writer believes would be of benefit to essentially all students accepted for entrance into a college of engineering would be as follows. (1) An explanation of the kinds of work performed by engineers, scientists and technicians as a background for formation of a choice of vocational objective. Information could well be included here covering certain professional attitudes that need to be instilled. (2) A review of high school mathematics through the medium of problem solution of an elementary technical nature. (3) Sufficient material to teach the language of chemistry and an insight into the meaning of the chemical equation. (4) At least an explanation of why technical drawing is considered the language of engineering. (5) Some elementary insight into problems of electricity, heat and mechanics with the purpose of creating interest in the later study of physics.

For most students only a part of these five objectives could be accomplished between college acceptance and registration. But, if no more were achieved than to get the student to spend a dozen hours on orientation reading and an equal period in reviewing mathematics, the results would be significant. Surely all students could be expected to give at least one week to such pre-entrance reading.

Conclusion

After looking objectively at this program one may well wonder why institutions have taken little active responsibility for encouraging students to prepare in this manner for college entrance. Considering our clear responsibility for doing everything possible to aid students in having a successful college experience it appears that this pre-college-entrance period of orientation and refresher study needs to be capitalized. To be most effective this program should be organized as a regular extension service. But useful results could no doubt be achieved on a more informal basis of recommended reading.

Engineering Literature and its Role in Pan-American Development[1]

By EDWARD P. HAMILTON

President, John Wiley & Sons, Inc., New York

In my talk to you today, I shall keep before me three related points of view: first, that of an engineer, because I was once in engineering; second, that of a person concerned with education; third, that of an individual, deeply interested in the technical and intellectual cooperation of all of the Americas.

Our meeting here in Brazil can also be said to have the same three related points of view. As engineers, we are extremely interested in the interchange of our own specialized knowledge. But we are also interested in extending our knowledge, both to our own colleagues in the countries we represent and to the engineers and scientists of future generations whom we shall have to educate. And naturally, we are here to foster and nurture unity which exists among us as engineers of a single geographical area: the American hemisphere.

This First Pan-American Engineering Congress, arranged by the South American Union of Engineering Associations, gives us therefore the opportunity to explore some of the engineering and the educational factors contributing to the progress and development of the American nations. The officials who have done such excellent work in organizing the Congress are to be congratulated for the results of their efforts. I am deeply grateful for the opportunity to be here and to express a few of my own thoughts on the influence and importance of technical book publishing in Pan-American development.

As we well realize, science and engineering today have no national boundaries. We engineers, throughout the Americas, and throughout most of the rest of the world, are all striving toward the same goal. Our role is one of inter-American cooperation in order to ensure that science and technology are developed to their fullest degrees with the aim of making the world a progressively better place to live in. We must not, engrossed as we are in the problems of our own professions and specialties, lose perspective and forget the necessity and importance of scientific interdependence among our nations if the full potential of technological advance is to be exploited for the peace, well-being, and security of new generations. We must emphasize the inter-American function in all our activity: in our own professions and work, in teaching the young people who will follow us, and in writing about scientific and technical achievement in the now internationally-circulated technical periodicals and books.

Scientists and engineers on the whole are among the most ardent proponents of the free and unrestricted communication of ideas to contemporaries in other lands and on other continents. As I see it, there is no better means for inter-American technical cooperation than through the interchange of scientific thought. Eminent authorities in science and engineering in our age are not concentrated in any one country or group of countries as they have been in the past. They are found everywhere.

[1] Presented at the First Pan-American Engineering Congress, Quitandinha, Brazil, July 20, 1949.

No matter what our native tongue, our background, our discipline, our national activities, we do speak the same language of science and technology. Our mathematical formulas and our physical laws are the same, even though in certain cases our nomenclatures are not alike. This is fortunate and must serve as a basis for initiating and continuing our hemispheric and world-wide relationship.

Inter-Continental Cooperation

Of course, international cooperation results from and is hastened by wartime necessity. But there is certainly no reason why science and technology should not cross national boundary lines in the practice of peace.

By lack of contact with colleagues in other countries, we have deprived ourselves occasionally in the past of some of the stimulus needed by science to progress further. On the other hand, by making international contacts, as we are doing at this meeting and as we shall do at future meetings of engineers throughout the world, we can actually help to make science and technology the dominant forces they should be.

For fear of creating the impression that we Americans have not been successful in our efforts to bring about inter-American cooperation in technical and scientific areas, I should like to mention certain activities which indicate that we have already made definite progress.

First—International meetings such as the great one we are attending today. Others especially worthy of mention are the Pan-American Mining Congress, the Inter-American Congress of Sanitary Engineers, the Sixth Pan-American Architectural Congress, the South American Congresses of Chemists, the fourth one of which I attended in Chile last year, which included chemists and chemical engineers from a number of countries outside of the South American Continent.

Second—The interchange of information between such great research institutions as the Instituto de Pesquisas Tecnológicas at São Paulo, the Instituto Nacional de Tecnológia at Rio, and Instituto de Tecnológia Industrial at Belo Horizonte, with similar centers in other countries.

Third—The interchange of professors and of students between our countries.

Fourth—The Pan-American Union which, especially in recent years, has devoted more attention to the joint application of scientific and technical resources to the solution of those problems limiting human welfare.

And from my own country there are the excellent journals Ingeniería Internacional Construcción and Industria published by McGraw-Hill Publishing Company.

The publication of Adelantos de Ingeniería, resulting from the combined efforts of the Engineers Joint Council's Commission on Latin America and the National Research Council.

The Research Council Bibliography of Scientific, Medical and Technical Books of the U. S. A., volume two of which, covering books issued from 1945 through 1948, is now, I believe, in the printers' hands.

Also the Quarterly Book List of our Library of Congress.

Mention should also be made of the excellent work of the Inter-American Committee on Scientific Publication which has established a program for regular publication in leading North American journals of outstanding papers by Latin American scientists and technical men.

Coming to the subject of technical books, I think that it will be acknowledged that their interchange between our countries has a profound effect in the internationalization of technology and science. All you engineers who are here today recognize their value.

You were taught from them; you are teaching the next generation with technical books. Books are your professional tools, and reflect your progress and achievements. The distribution of such books as we are speaking about—and naturally other printed technological information—has hastened the spread of

science and technology in a way that can hardly be matched by any other form of communication. Scientific developments have been followed almost immediately and invariably by books presenting theory, techniques, applications, and related matters. Today the engineer must not be any less practical than he was in the early days, when, as an example, the railroads were in their infancy. Now he must have in addition a sound theoretical knowledge. I might observe here that I have been impressed by the excellent working knowledge of higher mathematics among South American engineers of my acquaintance. Engineers also profit from a working knowledge of other branches of science, perhaps chemistry and biology, depending on their own specializations.

Reviewing the history of technical book publishing—apart from purely scientific works, some of which appeared as early as the 17th century—we see the beginnings in the late 18th century and the early days of the 19th. The evolution of formal technical literature has been gradual, although with occasional bursts of speed, particularly during wars. Tracing its development in the history of my own company, I find that we published some semi-technical books as early as 1815 and 1819.

Early Books Used Widely

Many of the early technical books published in the U.S.A. were famous and widely used throughout the Americas. Such works as Drinker's "Tunneling," Wellington's "Economic Theory of the Location of Railways," Whipple's "Art of Bridge Building," the first two published by my firm and the third by the D. Van Nostrand Company, and the Trautwine civil engineering books, all published in the '70s and '80s, were well known by an older generation of engineers in all our countries.

From these early days on, there developed a great North American technical literature, but up until World War II, Latin American engineers, from what I have been told, did not depend upon it to the extent that they did on books from Germany, France, Italy, and Spain. The Spanish publications, however, were largely translations from German or British books. From 1940 on through the war Latin American countries, perforce, turned to North America for their *imported* books. I emphasize the word "imported" because a Latin American technical and scientific literature is developing and in the future with its many able engineers and scientists is certain to grow. Just as one example of an excellent book from this continent I might mention the book on hydraulic engineering by Professor Dominguez Solar of Chile.

Looking around the bookshops of some of the capital cities of this continent one is impressed with the many splendid technical books originating in many countries; in other words, no country has a monopoly on technical books, any more than they have on able engineers or scientists.

Going back a little, up to the time of World War I, books of an advanced technical or scientific nature were rarely published in most of the countries of this hemisphere, chiefly because of the limited markets for them. This situation was especially true in the United States, where we publishers seemed to have been largely concerned with books at the undergraduate level. However, as a result of World War I, there were developments which hastened technological advance and the consequent need for more books dealing with specialized areas of science. Even then there were many gaps in the scientific literature in the United States and Great Britain which were left to other countries to fill, notably Germany and France, if indeed they were filled at all.

With the advent of World War II, engineers and scientists were faced with many new problems of staggering proportions—new direction-finding apparatus, higher-speed engines, construction of artificial harbors, the atomic bomb, and countless others. When peace came, publishers realized that we had to work

fast to keep up with new scientific developments. These efforts have led to investigation and publication in areas either completely new or undeveloped so far as the literature is concerned.

Unit Standardization Urged

The demand for these new books, in fact for all books, has been great in this post-war period, but there are difficulties that stand in the way of freer distribution from country to country.

First of all, there is the language barrier. Although a good many of us are familiar with each other's language, the majority of us are negligent in learning Spanish, Portuguese, English, or whatever language is required so that we can use technical books of foreign origin profitably and proficiently. We are, it is true, having our important scientific works translated into each other's languages, but there are problems which limit extensive translation programs, among the most difficult of which to overcome is that of costs. The cost problem is especially prohibitive in the conversion of English units into the corresponding metric units, and vice versa. It is my most earnest hope, if I may interject a slightly different thought at this time, that we will see in the near future a universal standardization of units, symbols, definitions, tabular and formular data and scientific nomenclature.

Another difficulty is the economic problem which prevents booksellers from freely importing books which are greatly needed. This difficulty is, unfortunately, likely to continue until the world's finances are straightened out.

Related closely to this difficulty is the problem of costs of publishing books today. The technical book by its very nature is much more costly than, for example, a novel, but all costs of book production have risen nearly 100 per cent in the past few years, and were it not for the greater demand for technical books since the war, their selling prices would have to be even higher than they are today. The publishers are making every effort to reduce costs.

Several new and highly original methods of book composition are now in process of development. One in particular in an experimental stage is being partly financed by the publishing houses. It is to be hoped that these methods will result in the reduction of costs and consequently of the selling prices of books.

In conclusion, I would like to say that I am sure that the engineering and scientific publishers are conscious of their responsibilities to the world of engineering and science. In preserving and in sharing technical knowledge, we can promote the kind of intellectual cooperation between scientists and engineers that is so necessary to the full development of the Pan-American world. All of us have much to gain from this development. We shall not only benefit our individual countries but we shall also help largely to make the entire free world one which sees peace and the well-being of all people as its ultimate goal.

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

Seattle, Wash. **June 19–23, 1950**

Value Judgments in Professional Education[1]

By ROBERT E. DOHERTY

President of Carnegie Institute of Technology

Education for the professions has been trying to catch up with the growing demands of the times. It has of course made seven-league progress from the days when the "curriculum" for would-be doctors and lawyers was an office apprenticeship with reading and janitorial duties, and for engineers merely an apprenticeship in the shop or field and the drafting room. But along with the progress in professional education has come even faster changes in the social structure, spurred on by new developments in science and technology. The speed of these developments has been so bewildering that one has even heard serious proposals for a moratorium on science and technology! The demands of the times have always kept ahead of education in the professions, and they are far ahead now.

One responsibility that no profession has adequately coped with has now assumed frightening importance. To what ends will professional men direct their energies and abilities? In our democratic country, where the people handle their own affairs, an intelligent answer to this question is mandatory, and the answer turns on a sense of values, especially the values by which professional men live and work. In view of atomic energy the question may, at the moment and on the surface, appear especially urgent in engineering and science; but this new development has merely thrown the spotlight on one side of a general problem which affects all professional education fundamentally. And I wish to urge attention to this general problem.

Fundamental Pattern of National Life Depends Upon Value Judgments

Let me begin by stating a general thesis from which my thoughts regarding this particular matter stem. Under the American system, professional men largely set the fundamental pattern of national life. The character of that pattern depends not alone upon their technical ability, nor yet upon whatever ability they may have in dealing with human and social situations; it also depends—depends critically—upon their attitudes, upon the way they look at things. These attitudes have some of their principal roots in value judgments; and these judgments, in turn, depend critically—or perhaps I should say *can* depend critically—upon education. Therefore any program for the development of a professional man, must recognize this fact or else fall far short of what I believe is now required for an enduring America. In other words, the ends toward which abilities are used are just as important in determining the outcome in national life and individual life as the abilities themselves, and those ends are determined when values are adopted. Hence recognition of the critical role of value judgments and therefore of the importance of cultivating intelligent procedure in arriving at them are educational "musts" of the first order. And it is these I wish to discuss.

I hope I may assume that the general thesis I have stated needs little elaboration, although perhaps I should discuss

[1] Address given at dedication exercises at the University of Illinois.

some parts of it. A word of definition may be in order. It may be asked, what is meant by "professional men" in the sense I have used it. I refer to men whose practice involves—or should involve—the application of a body of higher learning: lawyers, engineers, physicians, ministers, businessmen, industrial leaders, etc. I may be close to the fringe when I include business and industrial leaders. But certainly these fields are at least semiprofessional now and are on the road to becoming truly professional. And if among industrial leaders I include top-level labor leaders, as I do, I may be accused of being out of bounds. I can only say that if they are not professional men, they should be, because their responsibilities are professional in character; and as time goes on I believe that such leaders as are not must ultimately be replaced by men who are. All of these components constitute the group I have called professional men, who by the decisions they make day-by-day, year-by-year, determine local and national trends, and thus the pattern of national life.

I have said that the character of the pattern of national life depends not only upon the ability but also upon the attitude of professional men. A member of any practicing profession deals with practical situations that involve, whether he recognizes them or not, human and social elements as well as technical. The ability to understand and cope with all these elements to a degree commensurate with their importance in the situation, and the ability to point the solution toward proper ends, must, I assume, be taken for granted. But to develop these abilities involves extremely difficult educational problems—much more difficult than they are generally thought to be, even by many educators themselves, especially those who have not tried to do so. For these problems are not solved by telling the students what we know; they involve the development of analytical and creative ability, and also the cultivation of an intelligent attitude which will determine in a large measure the ends toward which such abilities will be directed.

There is another point about the general thesis. In urging the importance of values as a foundation of attitude, I need not dwell upon its other foundations. Certainly, family climate and traditions, including religious and political affiliations, and also the school program and the moors in which one is reared before college, all weigh heavily in one's attitudes, and in professional men all the more so in the degree to which formal attention to values is omitted from college education. The earlier influences become dominant in the absence of the other.

By and large the evidence is that the freshman enters college with little or no recognition or understanding, let alone appreciation, of the values he has adopted, willy-nilly, or of the other factors I have mentioned which together with values determine his attitudes. Moreover, there is ample evidence within my own observation and experience that in engineering when the student graduates from college, his recognition or understanding of the role of values in his life is little, if any, better than it was when he entered. Indeed, outside of the ministry, I have seen little evidence that the other professions are any better off in this respect than engineering. Hence I say again that to the extent that attention to values is omitted in college, to that extent the unidentified traditions and mores take over; they become a decisive part of the individual and determine his attitudes. And of course they remain so unless later intellectual, emotional, or other forces modify them. Don't misunderstand. I am not saying these unidentified values are not good. They may be. I am saying that they have been accepted without critical examination, that they are used unconsciously as a basis for decision, and that this is not good.

Moral and Spiritual Values Needed as Basis of Judgment

I have paused long enough to remind you of these other evident foundations of attitude so as to help us focus more sharply upon the critical role in professional education and practice of value judgments intelligently arrived at. Let us now consider this role.

It is twofold. The first role I have already mentioned: such judgments determine in part—or can so determine—the professional man's attitudes and thus the ends toward which his activities are directed both in his professional practice and in his life as a citizen and as an individual. Let me illustrate. The practicing engineer, in making decisions that confront him, must settle in his own mind, whether consciously or unconsciously, what relative weight he will assign to such values as personal advantage when this is placed alongside the values of ethical professional behavior; what relative weight he will assign to efficiency of labor-saving devices when this is placed alongside human and social welfare; to safety when this is placed alongside cost. And this engineer, as citizen, must likewise determine—again whether intelligently or by "hunch"—what relative weights he will assign to the value of his own time and personal convenience, on the one hand, and to the value of his service, as an educated man, to his community and to his country, on the other. He must likewise decide, as a citizen, as between the value of human freedom and the American way of life, with its attendant costs *to him* in money, time, and personal attention, and the values, as he may see them, of living under other forms of organized society. And as an individual, before he can live an intelligently directed and emotionally stabilized and satisfying life, he must adopt a set of moral and spiritual values as a basis of judging what is good and what is evil, and where his faith should lie; and a set of artistic and literary values for appraising and appreciating the great works in these realms. In other words, to achieve a well-ordered life that is rewarding in all of the activities of a professional man in his full stature, he must achieve a hierarchy of values, practically consistent, that will determine the ends toward which he will live and work: in short, a philosophy of life.

The second role of value judgments is related to the first: they constitute a logical basis for thinking. In the human and social realm such judgments are, *in this respect,* the counterpart of physical laws in the realm of science and engineering. They form the same kind of basis for constructive thinking—for analytical and creative ability. The primary difference is that physical laws are, of course, for all practical purposes, fixed, are not subject to opinion and choice; whereas value judgments are not fixed in the same sense, are subject to opinion and choice. Also, of course, one recognizes the intrinsic difference between a physical law and a value—that is, between a cause-and-effect relationship, on the one hand, and a chosen end, on the other. But in both realms intelligent thinking, whether the purpose is to understand or to determine what to do in a practical situation, must proceed from a logical base. For example, to determine how to go about a problem involving energy transfer, one of course falls back upon the Law of Conservation of Energy. Or, taking a case in the other realm, to decide what to do, as a citizen, about the problem of low-cost housing, one must look to his own values as the starting point in reaching his decision. Thus, there must be a foundation for intelligent thinking in either realm, and in the human and social realm where ends are so important, the values that are adopted by the individual form an essential part of that foundation.

Stages in Achievement of Intellectual Competence

If the point of view I have proposed regarding the essential role of values is

accepted, we may now consider what this implies in professional education.

Let me again turn to a general concept as a setting in which we may explore this question. It is a concept which, for good or ill, I hold after struggling with the problem of education for over twenty-five years. My observations have indicated that in the achievement of intellectual competence and maturity there are three stages. I do not mean that every student who achieves such competence passes these stages in succession; I do mean that among graduates (and of course among students) one can recognize such different stages of attainment —perhaps in different degrees in the same individual. Thus, the concept represents merely a convenient scheme of classification and definition.

The first stage—if I may indulge in radio parlance—is what I would call "quiz-kid" learning. One learns facts—merely facts. Such learning can hardly be called encyclopedic, because in the encyclopedia the facts are at least ordered alphabetically! I refer to the welter of miscellaneous unrelated facts and information that today, I am afraid, characterizes too much of the learning in both secondary and higher education. It is the kind a student memorizes from lecture, class, or study, and passes back to the instructor in a quiz.

The second stage is the organization of knowledge. This is the selecting and pulling together of related facts and information. But it is not merely this; it involves also another selection. After selecting facts and information that are *related,* one must then select from these the items that are *significantly related;* that is, those groups of related items that can be fitted together into an organized whole. This twofold discrimination, together with the organizing process itself is the way facts and information become useful knowledge.

One may picture this process. When such a new fact or idea is grasped by the student, he will, with the guidance of the instructor if he needs this, relate it to his existing knowledge by adding it, articulating it, to his growing tree of knowledge. If it is of fundamental significance, it may belong as part of the trunk, or even be a new root. One thinks of the roots as fundamental generalizations—for example, natural laws, economic generalizations, basic moral and political values. One thinks of the trunk as including corollaries and other derivatives of the basic generalizations, and also fundamental data that make these generalizations meaningful—for example, the space-time relationships that follow from Newton's Laws of Motion, the systems of units and the constants that go with them, the form of social organization that best fits the political values one has adopted and historical illustrations that support that form, and so on. And one thinks of the branches and foliage as further extensions of specialized learning—for example, a formula for a specific case, or a new variation in electric motor design, or a new court interpretation of the Taft-Hartley Law, or a new illustration of human fortitude. Such a body of knowledge, so organized, represents a master *gestalt*—if I may borrow a word from psychology—in terms of which further learning becomes both intelligent and interesting. And the achievement of such a gestalt represents what I have called the second stage.

Something further may be said about this second stage. Certainly it constitutes one of the legitimate aims of higher education in any field. If limited within the definition I have suggested, its end result for the student is at least the ability intelligently to understand and to think *about* what he has learned, and perhaps a basis for inspiration and personal satisfaction. However, if education is limited to these terminal results, it cultivates merely what I would call a "scholarly front"—an ability to talk and write in an interesting and impressive way *about* what one knows. But there remains a great gap. One has not learned how to struggle with the situations of life; he can think and talk about them, but he

cannot *do* anything about them; he has not cultivated an analytical and creative ability.

The achievement of this additional and higher ability represents the third stage of competence. It is the disciplined ability to analyze and the creative ability to devise means to an end.

Professional education may therefore be defined in terms of this "three-stage" concept. Its aim should be the achievement by the student of the second and third stages: which is to say the achievement of a foundation for his further learning and progress, so that after graduation he can continue to grow to his full stature as a professional man, citizen, and individual.

But our primary concern here is how to help the student achieve the second and third stages in connection with values. How can we help him learn to discriminate among values and to arrive at intelligent judgments? How can we best guide him to an effort to relate these value judgments to each other? How can we help him to learn how to use them as a basis for deciding what to do in practical situations?

Approach in Teaching Professional Judgment

Let me say at once that certainly I am in no position to give you the full answers to these questions. I do believe, however, that I am in position to define the general problem of the role of values in professional education, and I have done so. And I believe too that I can state a basis for the solution, and it is this I shall now try to do.

My own observation and experience have convinced me that the best way for a student to learn how to do something is to do it. This may require many attempts, if necessary under guidance, learning something further from each experience, until he can do it. Moreover, psychologists tell me that this makes sense. And this applies as much to the process of reaching intelligent decisions about values as it does to reaching intelligent decisions about anything else. If this view is accepted, then we at least know how to begin.

The first clear inference from this principle is negative. The student does not learn how to do such things merely by having someone tell him how or having someone do them for him. He must *do* them himself.

If we want him to learn how to discriminate among values and make intelligent judgments, we must give him the opportunity to face alternative values—confront him with what John Dewey calls a "forked-road situation." Thus confronted, how does the student make up his mind which way to go? Certainly not by being told which is the best way, for only he can decide which is *for him* the best way. Such a judgment is, or should be, a personal matter. Certainly not by having him choose merely on the basis of his family traditions and the provincial mores in which he was reared, nor on the basis of what he has read in the newspaper. If he is to decide intelligently, as we must insist that he do, then he must first learn how to do something else before trying to decide: he must learn how to select, organize, and use evidence.

This is a discipline of history, and at least one way of helping him to learn it is, for example, to have him take a course in history that is *pointed to this end*—that is, one in which cases are carefully selected with respect to their usefulness in the student's effort to learn how to deal with evidence. Needless to say in passing, this is not the traditional undergraduate course in history. Thus can he learn to infer from the written record, generalizations about nontechnical matters, including values.

History is not, of course, the only source from which to appraise values; one may not even consider it to be the most important source. Other subjects of study and one's personal experience may be as important, or more so. Neither is it the only source for learning how to generalize from evidence, because there

are other kinds of evidence. For instance, the engineering student learns to generalize—or should learn to—from dealing with quantitative data in the laboratory. But history's unique place in the problem we are considering stems from the fact that its primary discipline is the constructive use of evidence *from the written record.* And the student must learn such use before he is in position to make intelligent value judgments from evidence in such records.

Thus can he get a start at learning how to separate out relevant items of evidence, organize them into a meaningful relationship, and draw a generalization. And even while he is learning how to go about this process of creative analysis, the student will presumably deal with at least some cases that involve values; and later and broader study, if properly directed, will both sharpen his skill and bring him increasingly to the point of making value judgments that are intelligent, even if, at this stage, they are still tentative.

They must of course be tentative at first, because as time goes on the student may realize that a value he adopted earlier is in conflict with one he now sees reason to adopt. In that case, a new study and revision are necessary, since naturally the whole set of values he ultimately adopts must be practically consistent. By such a process the student can get a start in gradually approaching a hierarchy of values that are in a practical sense mutually consistent, and thus achieve in this realm of values what I have referred to as the second stage.

Value Judgments as a Basic Analytical Ingredient

We now come to the question how to help the student learn to think constructively in terms of such values. This involves precisely the same educational problem as helping him to learn how to think constructively in terms of any other general principle, for an adopted value is a principle. And if the educational approach I have proposed is accepted, the teaching method is clearly indicated: confront him with a practical situation the solution of which involves values, and require him to make an intelligent, well-ordered decision what to do in the situation and to justify that decision.

Every time he struggles through such a situation *in this way,* he has learned the better how to tackle the next one. And as he approaches intellectual maturity, he will come to think in terms of his adopted fundamental values as a matter of habit. In other words, he will have achieved an intelligent, professional attitude that will determine to what ends he will direct his energies and abilities. It will be a constructive attitude that impels him to take a position on important issues of policy, and not, through ignorance or lack of intellectual moorings and therefore of self-confidence, to retreat to a neutral corner as engineers are so likely to do; or worse still, to take an active position on the basis of "hunch" or opportunism.

But one may ask, What if such an education leads him to take the wrong position? This question is important, because it is frequently asked and thus demonstrates a confusion of the very thing we are discussing—namely, fundamental values. And when carried into educational policy, this anxious point of view represents the worst kind of aberration. To ask the question implies a lack of confidence in intelligent procedure, and disavowal of intellectual freedom, or a misconception of what I mean by values. It urges partisan indoctrination on one count and the "iron curtain" on all alternatives. As an example, it would urge that we indoctrinate students with Democracy but not mention anything about other ideologies. Such proposals are bad not only for the reasons just given; they are bad also because they are educationally ineffective. In the first place, an intelligent student easily detects an attempt to indoctrinate him, and his respect and confidence are thus lost. Worse still, even if the stu-

dent could be cultivated in such an intellectual greenhouse protected from every challenge of worldly weather, what will protect him when he leaves the greenhouse and must face the challenge of the outside world? If he merely accepts what persuasive teachers say, then he will presumably keep on learning the same way after he graduates. Having no deep-rooted convictions born of struggle, he is more likely to be easily swayed by the propaganda winds of the day.

What is needed in America is intellectual toughness, born of intellectual struggle, and resting upon a foundation of values built during that struggle. I have no fear of the conclusions which professional men, thus educated, would reach, for I have full confidence in intelligent procedure and place top value upon intellectual freedom. What I do fear is a teacher or an administration that insists on telling the student, in a partisan spirit, what the answers are—or what the teacher thinks they are. What is needed throughout higher education, as I view it, is more teachers and administrations that will insist on students achieving the second and especially the third stages of competence in regard to values, and will take the time and have the patience to solve the extremely difficult educational problem that is involved. For it is very far from being solved today.

But the stakes are high. The development of a new breed of professional men who not only can perform effectively in the technical part of their work, as they can now do, but also serve the additional functions I have outlined, may be a very important factor in the endurance of America. Leading educators in the professional schools of the country are today groping toward a new educational policy that would train their graduates to carry a responsibility now largely neglected—that is, to deal with the human and social factors in their professional problems.[2] But I am proposing that a further aim, as yet scarcely touched, be added—namely, a start toward the development of a set of values that will determine the attitude of the graduate—the ends toward which he will work and live as a professional man in his full stature, as a citizen, and as an individual.

[2] Education for Professional Responsibility (Proceedings of Inter-Professions Conference on this subject held at Buck Hill Falls, Pennsylvania, April, 1948), Carnegie Press, Pittsburgh.

College Notes

Dr. Ju Chin Chu, one of the younger chemical engineers to gain an international reputation in his field, has joined the faculty of the **Polytechnic Institute of Brooklyn** as an associate professor in the Department of Chemical Engineering. Since 1946 when he took his degree of Doctor of Science in Chemical Engineering at the Massachusetts Institute of Technology, Dr. Chu has been director of research in the Department of Chemical Engineering at Washington University, St. Louis, Missouri.

Paul P. Ewald, renowned pioneer of X-ray crystallography, from Belfast, Ireland, will assume the chair of Physics at the **Polytechnic Institute of Brooklyn.** As the new head of the Department of Physics, Dr. Ewald, who is the editor of *Acta Crystallographica,* the international journal in the field of crystallography, plans to return to experimental work in the field of X-ray diffraction and in other fields covering the physics of the solid state.

Faculty Personnel Factors and Promotions*

By JOSEPH WEIL

Dean, College of Engineering, University of Florida

In the kaleidoscopic pattern of college activities of sports, physical education, military training, social and professional fraternity demands, glee clubs, debate societies, bands, orchestras, college politics, and social events there must still be found time for lectures, laboratory work, and study. This must be done even though the student is required to secure employment to help defray his expenses and even if the married student finds his domestic problems encroaching upon scholastic activities.

But out of the total time available of 168 hours a week, a college professor is seldom able to see a student more than from 12 to 24 hours. If the professor is to serve as efficiently as the football coach, the faculty advisor of the fraternity, or the director of the glee club, he must use the few hours available to him effectively. If he does not, then, the student, in the face of the heavy demands on his time and not having sufficient time for sleep, will use the classroom for this purpose.

Selection of Faculty

The administration of the University should endeavor to select the professional staff with as great care as it does its other personnel. If the college is to attract the young men of the state, not only must there be a winning football team, an outstanding band, a beautiful campus, but also the "catalog" should portray the opportunities for study. Today, I fear, most college information pamphlets depict the beauties of the campus, the size and number of the buildings, the comfort of the dormitories, the opportunities for recreation, but they do not, at least in some cases, give adequate information about the staff.

Does this mean that the selection of the staff is not given careful consideration? Certainly nothing could be further from the truth. It does mean, I believe, that in the scramble for recognition, often in order to secure more students or larger appropriations, certain factors are played up prominently. Those faculty members who then assist in the growth of these public interest factors may then appear to reap benefits, while their colleagues busy with teaching or research are passed by.

Certain vocations such as the ministry and teaching are selected by individuals because of some inner feeling that they have what might be considered a calling for service to the public. Neither the teacher nor the preacher follows his vocation because of his desire for pecuniary gain or because he desires the plaudits of the crowd. Yet, I doubt whether there is anyone who does not desire to secure some recognition for outstanding accomplishment in his chosen field of endeavor. In the case of the teacher this recognition may take various forms. It may come in the form of satisfaction resulting from the gratitude of students who appreciate the efforts of a good teacher. It may come in the form of the gratification that a teacher secures in observing the rise to fame of successful graduates. Anyone could add many other forms of

* Presented at the meeting of the Southeastern Section of the A.S.E.E., University of South Carolina, April 7, 1949.

compensation which come to the conscientious teacher. It might be said that the amount of real satisfaction which comes as a result of his vocation will, in practically every case, be dependent upon the individual's successful performance in his profession. While many more or less intangible factors may be mentioned as a measure of success, most educators today desire—in fact, also require—more tangible and practical evidence in order to enable them to continue in their work. I refer particularly to financial remuneration. There is considerable feeling among many educators that this tangible evidence of success is not always as fairly allocated to individuals as are the more intangible factors. It is the purpose of my talk today to give from the administrator's viewpoint a picture of what personnel factors are considered important and which are taken into consideration by at least some administrators in the adjustment of salaries.

Factors to Consider

A conscientious administrator always endeavors to balance human aspects with practical administrative requirements in attempting to be as just as is humanly possible. It is but natural that he would like to give consideration to such matters as the size of an individual's family, any special financial difficulties which have arisen, and other matters which in no way can be considered as determinants pertaining to effective teaching. But the administrator is a liaison agent between the individual faculty members and higher administrative groups. He must be ready to justify every increase that he recommends. He must be able to explain any apparent differences in salaries between individuals doing approximately the same work. The administrator in an engineering school necessarily endeavors to find some means of measurement in order to be able to more accurately perform his task. He tries to synthesize the problem and then to apply measuring devices to the various elements. He takes cognizance of the fact that he is dealing not with material objects but with human beings with their infinite variations. He recognizes quickly that no measurements can be considered as accurate but must at best be an approximation to be used as a guide. Since I cannot speak authoritatively for any college other than my own, I shall endeavor to give the philosophy which has governed our policies pertaining to advancements and salary increases in the College of Engineering at the University of Florida. We know that what we have done is but the beginning of our efforts to bring forth a system which can be considered as equitable in making judgments of merit.

One policy which has been adopted has been to endeavor to base individual promotions and increases in salary upon an evaluation of the individual's qualifications. The mere fact that a person has a particular title or some special assignments is not by itself considered as a sufficient reason for a salary increase. An outstanding teacher may be worth more than a mediocre administrative officer. Salaries should be commensurate with individual worth. One should not have to do administrative work to secure the top salary.

It has not been our policy to attempt to meet offers which individuals might receive from elsewhere. This places a responsibility upon the administration to take steps that merited individuals receive salary increases commensurate with those they may later receive from elsewhere. When this cannot be done, other compensations should be brought forth in order to equalize the over-all compensation.

Faculty Evaluation

In order to determine what promotions and salary increases are to be recommended, meetings are held of the department heads of the College. All individuals, except those present, are then brought up for discussion and attempts are made to analyze them. A

large number of criteria are considered, which are listed here:

physical qualifications
intellectual qualifications
emotional qualifications
volitional qualifications

including morality, health, vitality, vigor, enthusiasm, integrity, honesty, cooperativeness, resourcefulness, appearance, and others

education
experience
teaching proficiency
membership and activity in professional societies
professional registration
other professional activities
value as a member of committees
research activities
student contacts
contacts with general public
general stability
years of service
honors

In attempting to grade these a seven letter system is used:

A—Outstanding
B—Good
C—Average
D—Low
E—Poor
U—Unsatisfactory
X—Not rated—not sufficiently well known

Let me say here that it is not intended to average these grades and so produce an over-all or weighted average. The various factors should not have similar weights for all classes of work. Considerable variation should occur in evaluating a young instructor and one of his mature colleagues. At best this analysis merely gives a sort of general picture upon the cross-section opinion of several persons who are in a reasonably good position to have accurate knowledge of the individual's qualifications.

The factors that have been mentioned above might be partially offset by a group of negative factors such as the following:

inability to express oneself properly
failure to be punctual
lack of cooperation
disgruntled or objectional personality
a trouble-maker
careless of safety conditions
too impatient
unavailability—not on the job
lack of judgment
poor health
unthoughtfulness or untactfulness

What Constitutes a Good Teacher?

Some men believe that they are exceptionally good teachers. They base this upon the fact that they are hard taskmasters; that they give out class assignments in a methodical manner; that they hold their classroom work on an assigned subject and permit no departure from it; that they demand a great deal of work from the student and that they grade it and return it to him. But while all these things are important, they, by themselves, do not make an outstanding teacher. Sometimes variations from such a routine procedure may be of real value from a pedagogical standpoint. A stimulating and sympathetic teacher, one who inspires his students to amass a large fund of knowledge, is a rarity and when he is found he should be compensated accordingly.

The amount of importance that can be attached to a particular rating on the rating sheet varies greatly for various persons. Some persons must help with administrative duties. It is this group who should be given added credit for the effectiveness of their contacts with students, with other members of the staff, and with the public. Research personnel need not necessarily be good teachers, although many of them are. All teachers need not do research. Certain traits, however, should be common to all of the professional staff of an educational institution.

Without attempting to arrange the factors discussed above in any particular order, lists were distributed among the faculty of the College of Engineering at the University of Florida. It was suggested that each member classify the factors enumerated into categories of relative importance. As a result of this the following factors were selected in order of importance:

teaching proficiency
experience
education

Then, but given less weight, came:

research activities
cooperation
general stability
student contacts and inspiration

Then, but considered of still lower importance, came these factors:

professional activities and contacts
public contacts
society membership
registration
committee value
years of service
honors

It must be considered that these evaluations are the opinion of faculty staff members and not administrative officials. It is of interest that evaluations secured from persons employed primarily as research workers differed little from those secured from the teaching group. The chief variations occurred as variations of items in a particular grouping. Research workers and teachers would necessarily interchange the top items in the first two groups.

Viewpoint of the Administrator

The administrative officer in evaluating some individuals would give added importance to such items as cooperation, student contacts and committee value. Yet every faculty member should not be called upon to do a large amount of administrative work. But since administrative work must be done, credit should be given to those individuals who share in it. While it is true that the basic objectives of a college must be the dissemination of learning and the advancement of knowledge, only about 40% of college expense is allocated to salaries for teachers and research workers. Those who help in the wise expenditures of the remaining 60% of the school's finances should be given credit for their assistance. Any person interested in college operations is well aware of the numerous administrative tasks that are required for efficient operation. Curriculum building, student counselling, committee work of varied types—all are necessary. The efficient operation of any university depends on these matters and teaching and experimentation cannot be effectively done without them. Those who do such work render services which should be recognized.

At the University of Minnesota it was found that for the period of 1913 to 1931 factors entering into promotions were of the order of importance given in column 1.*

	%	%
teaching	43.4	35.4
productive scholarship	27.6	22.9
student counselling	11.6	7.1
administrative work	11.0	9.9
public service	6.4	5.1

The second column gives the information for Indiana University.

The evaluation of the criteria considered will necessarily vary greatly, not only for different institutions, but even for different groups within any particular institution. Of importance in any study such as this is the fact that it gives to the individual faculty member a picture of an administrator who does not sit down arbitrarily to make promotions or to allot salary increases, but it gives him a chance to see what factors are taken into consideration. Furthermore when his rating sheet is considered by a member of the faculty, in many cases, his first action is to have him interrogate himself.

* AAUP, Vol. XXVII, Oct. 1941, p. 446.

Thus under "education" he asks what further studies shall I undertake. Here is an answer to whether or not it may pay to study for an advanced degree. Under "teaching proficiency" he may consider what he can do to improve his pedagogical methods. Thus, he may prepare himself more thoroughly for his classes. Since "research activities" are to be considered, here is an incentive to work on that problem that has always been so intriguing. Here, too, is a reason for joining and taking an active part in professional society work. One might even ask, "Can I afford not to belong to these professional societies if the salary is partially dependent on it?"

The equation for success contains many unknowns. As we accurately delineate these unknowns, our chances for success are greater.

It is my belief that the study of the rating sheet has resulted in stimulating staff members to activities that have been worthwhile. It has enabled them to better understand the problem of the administrative officer and has resulted in greater harmony. In the truly democratic way it gives the faculty member a chance to discuss his position with his department head. He, in turn, fortified by the composite opinion of a group can assist the staff member in materially improving himself.

Division Forum

Industrial Engineering

With the turn of the century we find a new area of thinking permeating the field of engineering instruction. One engineering school as early as 1908 introduced a curriculum and a department of Industrial Engineering. Since that time the growth of these departments has been a steady one. The 1940's reflect an accelerated recognition of the place of Industrial Engineering in the overall engineering program of colleges and universities.

To the end that those schools with Industrial Engineering Departments or organized options in other curricula can strengthen programs and to give guidance to those schools laying plans for development of this area of instruction, the A.S.E.E. Industrial Engineering Division is planning a program for the Annual Meeting at Seattle which should be thought-provoking and most profitable. Those attending the Troy meetings will recall the stimulating discussion of "What Is Industrial Engineering?" With that introduction the program at Seattle will continue with knock-down panel discussions of such topics as:

A. *The Industrial Engineering Curriculum:*
   1. Basic engineering core courses.
   2. Industrial Engineering core courses.
   3. Other courses.

B. *The Graduate Program in Industrial Engineering.*

C. *Who Should Study Industrial Engineering?*

That these topics will generate lively and heated discussion goes without saying. With panels of experts for each topic and with many others attending who have given these subjects real individual thought, the Industrial Engineering Seattle meetings should be memorable ones. Don't miss them!

EDITOR.—*A page in each issue of the* JOURNAL *will be devoted to constructive comments from the various Divisions of the Society. Manuscripts should not exceed 500 words in length and should be sent by the Division officers to the Secretary of the A.S.E.E.*

Federal Scholarships and Fellowships for Selected Engineering Students

By WALTER E. BLESSEY

Associate Professor of Civil Engineering

Introduction

Our whole system of higher education in the United States is reaching far too few persons with a program that is too low in quality. Certainly all of the land grant colleges need to intensify and broaden their work. To keep democracy in this country we must have enough minds that have been equipped to think broadly, deeply, and clearly. Instead of having 4 per cent of our population college graduates we should raise the percentage to at least 10 per cent.

In a study of higher education for the House of Representatives, 78th Congress in January 1945 it was found by questionnaires that almost all colleges and universities favor federal aid to students in the form either of direct scholarships or work aid, comparable to the student aid program of the National Youth Administration, in most all instances preferring scholarships. Federal competitive scholarships are strongly recommended by college and university administrators as one of the most important single means of equalizing educational opportunities and of aiding institutions of higher education. The committee making this study reported that the need and opportunity for research work in a very large variety of fields was of such magnitude and general recognition that it highly recommended federal assistance for such work.

History of Federal Aid to Higher Education

The federal government, beginning with the Ordinance of 1787 and through a long series of legislative acts, has continually encouraged and assisted institutions of higher learning. In so doing it has aided them in extending their activities and increasing their services over a wide field.

The methods through which such assistance has been given may be grouped as follows:

1. Grants for the founding and early maintenance of several private colleges.
2. Grants to states for land-grant colleges and state universities, both for general use and for the development and operation of agricultural experiment stations.
3. Grants for specific institutions: The United States Military Academy, the United States Naval Academy, Howard University and others; also for the education of the Indians.
4. Payment to both public and private institutions for specific services, both continuous and for the recent war emergency: agricultural extension; training of war workers in engineering, science and management; R.O.T.C.; Civilian pilot training; Army and Navy college training programs; and research.
5. Scholarships and student aid in various forms for students enrolled in both privately and publicly controlled colleges and universities; the college work program of the N.Y.A.; the rehabilitation of disabled veterans under Public Law 16, 78th Congress and of civilians disabled in war industry and otherwise (Public Law 113); and since June 1944, education of veterans under Public Law 346 (The G. I. Bill), 78th Congress; the nurses train-

ing program of the Public Health Service; and the scholarships granted through the Department of Commerce for students to study meteorology.

6. Funds for refinancing through the Reconstruction Finance Corporation and for construction under the Public Works Administration, available only to publicly controlled educational institutions.

There is no consistent pattern running through these federal legislative acts but it is evident that the Federal Government has made and is making use of higher educational institutions.

Necessity for a Program

The object of a federal scholarship and fellowship program is to discover and develop scientific talent particularly in American Youth, thereby promoting the development of science and technology. No research program could operate effectively for long without that talent. The one greatest risk in the democratic educational system maintained in this country is its danger of bringing about too great uniformity on the level of mediocrity. Democracy, more even than other forms of political organization, demands that each individual be stimulated as far as possible to rise to his highest level of ability. If young people of superior capacity are taught in mass production methods of education and fail to put forth their best effort they will not achieve their best development. Society will thus be deprived of the contributions they should have been prepared to make.

The schools, colleges, and universities everywhere are striving to cope with this difficulty in our democratic system of education. They are meeting with greater and greater success each generation in overcoming the problems of educating all children in a common school system. But they will be assisted greatly if the Federal Government establishes a program of scholarships and fellowships designed to encourage the further education of young people of exceptional talent. Such encouragement will include grants to help retain in college and university talented young people who would not otherwise continue. But it will also include nonmonetary recognition of talented young people who do not need the money. In fact, the greater significance of a program of scholarships and fellowships lies in the the psychological effect of the Government's putting its stamps of approval on the efforts of educators to identify and develop to the highest level young people of superior ability. This program is, therefore, not only intrinsically important from the standpoint of stimulating research, but it is at the very center of the efforts to gear up the educational system of the country. It must not be regarded as significant alone because it will assure an adequate flow of competent personnel to work on the research projects, important though that is. Its significance is far greater in that it is bound to improve the standards of all American education.

The question may be raised as to whether under present arrangements practically all of the most competent young people do not already complete high school and enter college. A good many studies have been made of that question. Some of these have been State-wide. Every study reveals essentially the same facts, namely, that for every young person standing in the upper quarter of his high school class in achievement who goes on to college, another young person of equal achievement does not go on to college. Similarly, those dropping out of high school before they graduate include many of the most able young people. Army classification tests as related in *Science* by Psychologist Adjutant General W. V. Bingham showed that among 105,000 men who made the top third on the tests over 2000 had never been beyond the eighth grade (some much less) and nearly 8000 had only one to three years high school.

There are many reasons for this, but two are perhaps most dominant:

a. The most able young people are the ones who are in greatest demand by employers.

b. The other reason is a financial one. They dislike to be a further financial burden upon their families. Sometimes the parents are quite unable to help them with their college expenses no matter how much they would like to do so. In such circumstances young people of ability (and they are frequently also of high sensitivity) do not think it appropriate to go on with college.

A few decades ago students could enter college and make their own expenses easily. It is much more difficult for them to do so today. Tuition fees and living costs are higher than they used to be. Opportunities to work one's way through college are less common in proportion to the number of college students than they once were. Hence young people without means tend not to enter college or, once having entered, tend to drop out.

It must not be concluded from the above, however, that the sole purpose of the scholarship program is financial aid. The honor attached to selection will be an incentive to a large number of young people who not only do not need the money but might even be harmed by it.

The Scholarship Program

Scholarships should be of at least two types, including honor scholarships without stipends and honor scholarships with stipends. These stipends should vary according to the financial needs of the students. There are strong arguments for including also honor scholarships providing stipends for full or partial service called work scholarships, and honor scholarships entitling the student to a loan. These various types are necessary in order that the scholarship program shall fit in properly with the prevailing practices on the various college and university campuses.

In order that the system of scholarships shall accomplish this purpose, the following must characterize its operation:

a. Some of the awards must be made not later than the time young people graduate from the high school. Only thus can the superior young people be stimulated to enter college.

b. Some awards must be available to students already attending the several types of colleges and pursuing courses in any field of study. High native ability is not limited to students attending any particular type of institution nor to those studying any particular subjects. Furthermore because of the variety of organizations prevailing in institutions of higher learning, the scholarships should not be rigidly limited to undergraduate schools.

c. The awards must be based upon criteria recognized by the young people themselves as effective in identifying unusual competence. These criteria will no doubt include examinations designed to test native ability, evaluations by teachers and others who know the young people, and grades obtained in high school and college.

d. The area covered by the scholarship competition must be large enough to make the award carry a distinct honor. It is believed, therefore, that the competitive area will need to be as large as a State.

e. Scholars should be authorized to attend any approved institution of their choice.

To accomplish the basic purposes of the scholarship program the form of administration most effective should be as follows:

The unit of administration should be the State. A scholarship board representative of the State department of education, the high schools, colleges, and universities should be set up by the legislature in each State. This board should select the young people to whom scholarship awards of the various types are to be made, and be responsible for carrying out the program. The scholarship certificates should, however, be issued by the Washington office, endorsed by the appropriate officer of the State or city scholarship board. In this way it would carry in the mind of the recipient the highest possible recognition.

The Fellowship Program

The fellowship program has as its principal purpose the encouragement of the more mature talented students to continue their studies. These men and women, usually college graduates and often well advanced in their special fields, are competent to render technical and scientific help on research projects. They are usually prepared to fill positions in the community of considerable responsibility and at reasonably good pay. In some cases, they are so determined to go further with their education that they will do so regardless of the sacrifices entailed. In other cases they yield to the natural impulse to accept employment. In either circumstance a fellowship will be helpful. In the first case the fellowship will ease the strain, allow for greater concentration on the educational and research program, and enable the fellow sooner to reach his period of maximum productivity. In the case of those who have accepted employment at less than their maximum scientific effectiveness the fellowship will assure further study and research with the likelihood that the fellow will pursue a life of scholarship on a higher plane of service.

Certain it is that if the country is to have the greatest scientific (both natural and social sciences included) and technological development, every effort must be made to retain in the research program as large a proportion as possible of such young people of proven research ability. It is common knowledge that many research projects contracted for during the war could not be carried out as promptly as desired because competent research talent was not available. There are universities today which cannot accept funds offered to them for very important research projects because they have not, and cannot, recruit sufficiently competent research staffs to undertake the work.

To accomplish the principal purposes of the fellowship program, the following conditions must be met:

a. Selection as a fellow must carry with it distinct honor.

b. Stipends must be adequate to relieve the fellow from needless worry about finances.

c. The conditions for continued graduate study must be excellent and participation by the fellow in research projects must be on a high intellectual level, not on the level essentially of clerical, manual, or routine labor.

d. The number of fellows must be strictly limited to those of the highest order of ability.

To meet these conditions:

a. Awards must be made on a Nation-wide basis. Selection made on a smaller area basis will not carry the honor required to appeal to the men and women of highest talent. However, those fellows who are to devote an appreciable amount of time on research projects must be selected on nomination of the directors of the research projects to which the fellows are assigned.

b. Fellows must be encouraged to study at universities where facilities of staff and equipment in the fellow's chosen field are excellent, or at research agencies which are prepared to make the research experience richly developmental for the fellow.

To administer such a fellowship program will require centralized direction with a director in the Federal office assisted by an advisory committee representing the leading university associations and research agencies. Awards should be attested by a certificate signed by a well recognized Federal official.

Reports to the President

On February 15, 1948, Mr. George F. Zook, Chairman of the President's Commission on Higher Education, reported to President Truman.

The proposals of the commission looking toward the elimination of economic status as a basis for college attendance include the establishment of an extensive

system of Federal scholarships and fellowships.

The proposed scholarship program would involve a Federal appropriation of $120,000,000 to be available for the fiscal year beginning July 1, 1948, and to increase until 1952 in such a manner as to provide financial asistance to 20 per cent of the non-veteran students enrolled in college and universities.

These funds would be allocated to the States on the two-fold bases of the number of high school graduates and the population 17–21 years of age in each State. The recipient of the scholarship or grant in aid would be free to select the institution of his choice; a State commission on scholarships would determine the amount of the scholarship granted to each individual on the basis of his financial need. The Commission proposes that the maximum allowance to any individual be $800.00 for an academic year.

In order to meet the need of selected students who wish to pursue graduate work, the Commission recommends the establishment of Federal fellowships of $1500 each. It is proposed that 10,000 such fellowships be awarded for the academic year 1948–49, 20,000 in 1949–50, and 30,000 for each of the next succeeding years. Recipients of the scholarships will be selected on the basis of national competitive examinations.

Through this program the Commission accepts the premise that:

"Only as the opportunity for higher education is equalized for every potential student who has the interest and the ability to profit from college and university study at both undergraduate and graduate levels, can the ideals of democracy in education be realized. The program of scholarships and fellowships here proposed is not for the welfare of the individual alone but is vital in the national interest."

The commission urges a greater sense of unity between general education and specialized education. It decries the apparent breach that has been built up between education for living and education for earning a living. Colleges must find the right relationship between specialized training on the one hand aiming at a thousand different careers and the transmission of a common cultural heritage toward a common citizenship on the other.

Mr. John R. Steelman, Chairman of the President's Scientific Research Board, reported in 1947 to President Truman that a major factor in our national survival may reasonably be said to be the rapidity with which our scientific knowledge and the consequent steady improvement of our technology can be advanced.

The first indispensable resource necessary for this advancement, the report points out, is an ample supply of highly trained scientists and technicians. Today there are serious shortages in this supply.

As to the manpower shortage in science, the report concludes that our scientific strength depends neither solely upon our present supply of scientists nor upon those students now being trained. It depends ultimately upon a steady flow of able students into our colleges and universities. Most institutions are operating today at virtual capacity—thanks to the Veterans' Readjustment Act. But veterans already are beginning to exhaust their benefits; and it is clear that further steps must be taken soon, if we are to continue to improve the quality and size of our scientific manpower pool and to increase the scope of our research and development program.

Recent Bills Before Congress Affecting the Program

Two bills now before the 2nd Session of the 80th Congress affecting the program are H.R. 4852, and the Pepper Bill, S. 1131.

The most recent Science Foundation Bill is H.R. 4852 which is now before the House Committee on Interstate and Foreign Commerce. It was introduced January 6, 1948. This bill proposed to established in the executive branch of the Government an independent agency to be known as the National Science Foundation which would abolish the Office of Scientific Research and Development.

The Foundation would be authorized to do the following:

1. To foster and encourage a national policy for scientific research and scientific education.
2. To initiate and support basic scientific research by making contacts or other arrangements (including grants, loans, and other forms of assistance) for its conduct.
3. To initiate and support scientific research in connection with matters relating to the national defense by making contracts or other arrangements for its conduct.
4. To grant scholarships and graduate fellowships in the sciences.
5. To foster the interchange of scientific information among scientists in the United States and foreign countries, and
6. To correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups.

Of the five Divisions set up by the bill the Division of Scientific Personnel and Education would administer programs of the Foundation relating to the granting of scholarships and graduate fellowships in the mathematical, physical, biological, engineering and other sciences.

The Foundation would be authorized to award scholarships and graduate fellowships for scientific study or scientific work in the sciences at accredited non-profit American or foreign institutions of higher education, selected by the recipient of such aid, for such periods as the Foundation may determine. Persons shall be selected solely on the basis of ability.

The Foundation would maintain a register of scientific and technical personnel and in other ways provide a central clearinghouse for information covering all scientific and technical personnel in the United States and its possessions.

The Pepper Bill S. 1131 is before the Senate Committee on Labor and Public Welfare which has held no hearings on it. It proposes: to establish scholarships and loan programs for students in the eleventh grade and above. It proposes an appropriation of $250 million to establish a revolving fund for the loan programs and provides that any interest or repayments collected shall be credited to the fund. For scholarships it proposes an appropriation of $80 million for fiscal 1948, increasing annually to $150 million for fiscal 1951 and thereafter "such sums as Congress may determine to be necessary."

Both loans and scholarships are to be apportioned among the States on the basis of a formula which takes into account the number of young people from 14 to 26 years and the per capita income.

State plans approved by the Commissioner of Education are required, including the establishment or designation of a single State educational agency as the sole agency for carrying out the State plan.

At least 10 per cent of a State's apportionment is to be expended for aid to students in the eleventh and twelfth grades, at least 30 per cent to aid undergraduate college students, and at least 20 per cent to aid students at the graduate level.

Scholarships or loans shall not exceed $125 per month for students without dependents, $150 per month for those having one dependent, and $175 a month for those having two or more dependents.

Any person may be eligible for a scholarship or loan upon application therefor approved by the State educational agency. Loans are to be represented by a promissory note to mature 20 years after the last payment to the student and to bear interest at 3 per cent per annum.

Scholarships and loans will be continued only so long as the student's work is satisfactory to the institution which he is attending, and no scholarships or loan will be made to anyone receiving educational benefits under the "G. I. Bill."

Discrimination on account of race, creed, color, sex, religion or economic status is forbidden, except that separate arrangement may be made in States which require segregation of races.

No Federal or State agency is permitted to exercise any control over personnel, administration, curriculum, or programs of instruction of institutions, or to exercise any influence upon the choice of an institution by an applicant.

Conclusion

The federal government has always been interested in aiding higher education but never with the keen interest that is now evidenced by our legislators and statesmen in the advancement of science and technology. Therefore if a federal program of scholarships and fellowships materializes, as surely it must, then, if it is to achieve its purpose, we as engineers and educators must be prepared to lend assistance to our government in the selection of the most qualified potential engineers in that vast reservoir of American high school students.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	Spring, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 13, 1950	D. S. Clark, Purdue University
Middle Atlantic	Columbia University	Dec. 3, 1949	R. T. Weil, Jr., Manhattan College
National Capital Area	Washington, D. C.	Oct. 4, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Rochester	Nov. 18–19 1949	H. W. Bibber, Union College

Constructing a Mathematics Achievement Test*

By WILLIAM C. KRATHWOHL

Director of Tests, Institute for Psychological Services, Illinois Institute of Technology

The reasons for selecting mathematics instead of some other subject to describe the construction of an achievement test are two-fold. First, methods of construction for a mathematics achievement test can be applied to many examinations given in engineering schools. Second, the methods of construction which will be described have actually been used in making several achievement tests in mathematics, physics, and chemistry. Experience with them was obtained at the Illinois Institute of Technology when the faculty had to construct achievement tests in mathematics, physics, and chemistry twice a year for the semi-annual scholarship examinations.

The first step in constructing an achievement test is to decide what is to be measured, such as information, skills, techniques, memory, and ability.

The next step is to decide whether the type of examination to be used is a subjective one or an objective one, because the techniques for constructing a subjective examination are quite different from those for constructing an objective type. For instance, an objective examination generally uses many more questions than the usual subjective examination. If an objective examination is selected, one of the various types of objective examinations must next be chosen, such as true or false, matching, completion, and multiple choice types. In the case of the scholarship examinations, the multiple choice objective type was chosen with five responses, and this is the type which will be discussed.

The third step is the collection of problems. Such a collection can be made by the author of the test as he decides what part of the subject should be known. Other members of the department involved also can be asked to submit lists of questions. Oftentimes, examinations which have been used in the past will yield good material. In any event, many more questions should be obtained than can possibly be used so that a number of examinations can be made. Later these tests can be refined, revised, and reduced in number until several good examinations emerge.

The fourth step is to decide on the length of an examination and this will depend on the time available. A rough rule for the number of questions for the multiple choice type of examination in algebra, physics, and chemistry is to allow anywhere from 6 questions per minute for a true or false type to 2 minutes per question for a difficult multiple choice type with 5 choices. These are rough approximations since the time needed for most students to complete a test depends, among other things, on the difficulty and complexity of the questions which are asked. In any case, a check on the time should be made by having some member of the department take the test and multiply his time by 2 or 3 where the examination is objective, as in this case. This is in contrast to the essay type of examination where the rule usually employed is to multiply the instructor's time by 4 or 5.

* Presented before the Division on Educational Methods at the Annual Meeting of the A.S.E.E. in Troy, New York, June 1949.

Construction of the Tests

When the group of questions has been selected for the examination, the work of the author of the test begins to get more difficult. He has two tasks to do: one is to arrange the problems in order of difficulty from easy to hard, and the other is to select the wrong answers or misleads.

The reason for arranging questions in order of difficulty from easy to hard, is to eliminate as far as possible a personality factor. There are students who have the good sense to skip a hard question and go on to the next one, but there also are students who regard a hard problem as a challenge, no matter how emphatically they have been advised to do otherwise, and who therefore spend too much time on a question which happens to be difficult for them. The result is that time is called before they have had a chance to demonstrate what they know on the easier questions. The ideal situation, which probably never occurs, is to have an examination so arranged in difficulty that a student can answer all of the questions up to a certain item which is the limit of his knowledge, and none beyond that point. The first arrangement of questions on the part of the examiner must of necessity be a matter of guess work. After that it is possible to compute the difficulty of each question for a certain type of student population and thus to improve the test for that population. Since the difficulty of a problem is, to a certain extent, a function of its situation in a test, other revisions can improve each preceding revision until the difficulty of the problem, if it varies, begins to take on some stability.

The other task, that of selecting misleads, is the more difficult one and depends, in the beginning, very largely on judgment and experience. The task can be lightened considerably by making the fifth mislead in every question "All suggested answers are incorrect." Not only does such a choice reduce the amount of work involved from finding 4 misleads to finding 3, but it also definitely serves to improve the examination by reducing to a great degree the effect of chance in guessing the right answer; furthermore, it prevents the author of the test from making certain mistakes. If by any chance the author himself makes an error in what he intended to be the right answer, the correct answer automatically becomes No. 5. Some misleads will come from the author's own experience; others will come from experienced teachers in the department. Then too, some studies can be consulted on the way that students think, such as the findings of Keller, Shreve, and Remmers (4, 5) who made a number of reports on common errors in mathematics. There are two other methods which were used at the Illinois Institute of Technology and which yielded very fine misleads. One was to call for volunteers from the secretaries at the Institute, who had recently graduated from high school, to work the problems in the test. The other method was to issue a first edition in which the fifth mislead, "All suggested answers are incorrect," never was the right answer. A special answer sheet was used with a space to the right of this mislead in which the student was directed to write what he thought should be the right answer if he chose mislead No. 5. Some of the best misleads were obtained by this second method where a number of students gave the same incorrect answer. Excellent suggestions for compiling misleads are also given by Adkins (1), pages 56–64.

After the misleads have been chosen, a very important part of test construction is to decide in which positions to place the correct answers. In order to reduce the effect of chance and what is known as pattern marking, ⅕ of the correct answers should be choice No. 1, ⅕ should be choice No. 2, and so on up to No. 5. In particular, if choice No. 5, "All suggested answers are incorrect," is always used for a mislead, it should be the correct answer in ⅕ of the problems.

A method of making sure that the correct answer occurs the proper number of times in each of the five positions, such as 12 times in each position for a 60 question test, is to write the number 1 on 12 pieces of paper, the number 2 on 12 pieces of paper, and so on up to the number 5. Place these 60 pieces of paper in a box, shake the box well, and then draw out the pieces of paper, one at a time. If the first drawing is No. 2, the correct answer for question No. 1 should be placed as the second choice.

Directions and Scoring

After the questions for the examination have been selected, but before the test is printed or mimeographed, an important task remains, that of writing the directions. These should be written as simply as possible, using words with a small number of syllables and employing simple short sentences. At least one and preferably more typical illustrations should be added. Writing directions is an art which some people possess naturally, but much can be learned about good understandable writing from a book by Flesch (2).

Scoring a multiple choice objective test presents another problem. Some authors of tests prefer to count only the correct answers. Others prefer to correct for the element of chance in a five choice test by using the formula, rights minus one quarter of the wrongs. The advantage of a correction for guessing is that it eliminates the personality factor of taking a chance. Under the first system of scoring, a cautious individual who takes no chances is penalized when he is competing with a daring individual who takes a gambler's chance on every question which he does not know.

Revisions of Tests

After a test has once been given to a large enough group of people, at least 100 and preferably many more, it can be refined and revised to make a much better test by examining each question of the test for three items: the usefulness of the misleads, the difficulty of each question, and the index of discrimination of each question.

To find the usefulness of the misleads, a count should be made of the number of times each incorrect answer is used. If a mislead is never chosen or used only a very few times in comparison with the other misleads, it contributes nothing to the examination and should be replaced if possible by a better mislead. When choice No. 5, "All suggested answers are incorrect," is selected by an unusually large number of students, the implication is that the students can think of more wrong answers than their professors and some of the weaker misleads should be improved.

The next item to be investigated is the difficulty of a question which is defined to be the per cent of pupils out of the total number who answered the question correctly. Questions which are answered correctly by a small per cent of students are considered more difficult than those which are answered correctly by a large per cent. If the examination is to be used on the same kind of students, all questions then should be rearranged in order of difficulty, from easy to hard.

In the revised test it should be noted that the difficulty of a question will sometimes change, since the difficulty of a question seems to be partly a function of its position as is shown by Monroe and Englehart (6), page 187.

The question as to which problems should be kept and which should be rejected on the basis of difficulty usually can be solved by retaining those problems which are answered correctly by 30% to 70% of the group as has been shown by Thurstone (7). However, in some cases it is advisable to go beyond these limits. For instance, a good rule to follow is to make at least the first question so easy that everyone can answer it and thus acquire some self-confidence. If the examination is to be a competitive one, enough difficult but fair questions should be inserted to separate the best pupils of the group from each other and

from other members of the competing group.

Discriminatory Value of Problems

Finally, to make the test even better, the discriminatory value of a problem should be computed. Briefly such a value shows how well a particular question separates the persons who were most successful on an examination from those who were least successful. For instance, if as many persons who made scores in the upper quarter of the group answered the question correctly as did those from the lower quarter, the item contributed nothing toward separating those who did best on the examination from those who did poorest, and hence is a useless question. There are many methods of computing this discriminatory ability of a question, some of which are shown in Guilford (3) pages 295–297 and in Monroe and Englehart (6), page 184.

For most purposes, however, these very fine instruments for measuring the discriminatory power of a question are not necessary, particularly since some of them are rather laborious to apply. An easy method which gives roughly the same result is to compute an index of discrimination called D. To compute D, the whole group of examination papers, or a random sample of at least 100 papers, are arranged in descending magnitude on the basis of total scores, from the highest score to the lowest score. From these, the upper quarter and the lowest quarter are selected. Next, for a given question the per cent is computed of those in the upper quarter who answered the question correctly and then the per cent of those in the lower quarter who answered it correctly. If these per cents are U and L, then $D = U\% - L\%$. Thus if 70% of the students in the upper quarter, as measured by the total test, answered a question correctly and 20% in the lower quarter, $D = 70\% - 20\% = 50\%$ or 0.50. The limits of D are from -1 to $+1$. Experience has shown that D should be larger than 25% or 0.25. Problems with D lower than 25% should be rejected, unless there is a special reason for keeping them. Illustrations of the computation of D are shown in Table 1.

TABLE 1

SAMPLE DISCRIMINATORY VALUES

	Problem A	Problem B	Problem C
Upper quarter	80%	40%	10%
Lower quarter	20%	40%	15%
D	60%	0%	−5%

In Table 1, for problem A, 80% in the upper quarter answered the problem correctly, but only 20% in the lower quarter. Since $D = 80\% - 20\% = 60\%$, this is an excellent problem, as far as its ability is concerned to separate the best students from the poorest ones. Problem B is a poor problem because as many persons in the upper quarter answered the question correctly as did those in the lower quarter, and hence the problem fails to discriminate between the best students and the poorest ones. Problem C with a negative value of D also is a poor problem. It is very possible that it is so difficult that it becomes a guessing problem where the weak students, as sometimes happens, are better guessers than the bright ones.

Whenever D becomes very small or negative for a problem which the author thinks should be an acceptable problem, the key to the answers should be examined to be sure the author has not made a mistake. Errors in the key on the part of the author will frequently show up as problems of great difficulty or low discriminatory power.

When a number of examinations have been made so that a fairly large number of problems has been obtained for which the difficulty and the discriminatory values are known, these problems can be filed in a card catalogue with one problem to a card. Thurstone (8) has shown how from this collection of problems,

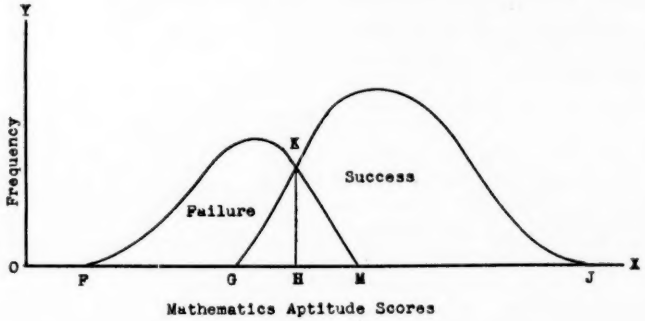
other examinations can be made by selecting problems whose characteristics are fairly well known and how such a collection of problems can be increased, without materially affecting the entire examination, by adding a few new problems each time.

Tests for Predictive Use

Examinations sometimes are used for predictive purposes, such as predicting success in a subject from an aptitude test or predicting success in college from an entrance examination. In such cases, it is necessary to compute what is called a critical or cut off score. In computing such a score, it is necessary to determine in advance what is to be measured and which instrument will best do the measuring. The latter problem usually is solved by finding correlation coefficients between various tests and grades or scores in a subject. When a good predictive test is found, the next problem is that of finding the critical score. A definition for a critical score on a test is a score above which the odds are in favor of a student making a satisfactory performance and below which the odds are against him. An excellent discussion of critical scores is given in Guilford (3), pages 181–187.

To see how such a score is computed, suppose that a certain mathematics aptitude test is a good predictor for success in college algebra. First a trial run is made of students who have taken the mathematics aptitude test and who also have taken a course in college algebra and received a grade in that course. Suppose that the grading system is such that grades A, B, and C are considered satisfactory or passing grades, whereas grades of D and E are considered as unsatisfactory or failing grades.

The critical score is obtained by drawing a graph as in the graph.



Mathematics aptitude scores are plotted on the x-axis, and the number of students making passing grades or failing grades, as the case may be, on college algebra is plotted parallel to the y-axis. The curve GKJ is obtained by plotting the number of students who have passed the course against their mathematics aptitude score. Similarly, the curve FKM is obtained by plotting the number of students who failed the course against their mathematics aptitude score.

If the letters G, H, and M, which stand for points, are also allowed to represent their respective mathematics aptitude scores, then it is obvious that the critical mathematics aptitude score lies somewhere between G and M. The reason for such a statement is that all students who have a mathematics aptitude score greater than M have passed the course, whereas all students who have made a mathematics aptitude score less than G have failed the course.

The critical mathematics aptitude score

in Fig. 1 is defined to be H, which is the abscissa of the point where the curve FKM intersects the curve GKJ, and for this reason, if a score is selected higher than H, it is true that there will be some students who fail the course, as is seen from the curve KM; but it is also true that there will be more students who pass the course for every mathematics aptitude score greater than H, as is seen by the curve KJ. Hence, the odds for a student who makes a mathematics aptitude score greater than H are in favor of his passing the course. On the other hand, if a score is selected lower than H, it is true that some students with this score will pass the course, as is seen by the curve GK; but it is also true that more students will fail the course for every mathematics aptitude score less than H, as is seen by the curve FK. Hence, the odds for a student who makes a mathematics aptitude score less than H are against his passing the course. At H the odds are even as to whether a student will pass or fail the course in college algebra. Hence, H is defined to be the critical score. If the mathematics aptitude test is chosen as one of the tests for an entrance examination and it is desired to select only those students who have the best chance to pass college algebra, then the least injustice will be done to the applicants for admission, if those making a score higher than H are admitted and if those making a score lower than H are rejected.

In an actual situation it never is necessary to plot the curves as is shown in Fig. 1. The critical score can be computed by any engineer, since all engineers know how to interpolate. An illustration is given in Table 2.

In Table 2, the numbers in the fourth column are equal to the number who passed minus the number who failed. The critical score is such a score that the number who passed equals the number who failed. Hence, it is necessary to know what mathematics aptitude score will give a value of zero in the fourth column. This score obviously lies $\frac{2}{10}$ of the way from 55 to 60 and, hence, equals 56.

TABLE 2

COMPUTATION OF A CRITICAL SCORE

Mathematics Aptitude Score	Number Passing	Number Failing	Difference
60	12	4	8
55	9	11	−2

Unfortunately in actual practice the situation sometimes is not as simple as Fig. 1 would seem to indicate. For instance, the success curve may cross the failure curve several times, and occasionally the failure curve may lie entirely within the success curve. Such cases mean either that the test used for predictive purposes is useless or else that the population used to compute the critical score is not large enough to overcome the errors which always are present in any testing process.

The method used in Fig. 1 for determining the critical passing or failing score, H, can also be used to predict from the proper aptitude test, the score above which the odds are in favor of a student receiving a given grade. If it is desired to know the score on the aptitude test which will separate the A students from the B students, all that is necessary to do is to replace the success curve by a curve showing the distribution of students making an A and to replace the failure curve by a curve showing the distribution of students making a B. The abscissa, H of the point K, where the curves cross will give an aptitude score, above which the odds are in favor of a student making an A and below which the odds are in favor of his making a B or a lower grade.

Illustrative Examples

Some illustrations of the kinds of problems to be found in a mathematics achievement test are given in problems A, B, and C.

PROBLEM A

$\frac{1}{4}$ divided by 2 is equal to

(1) $\frac{1}{2}$ (2) 8 (3) $\frac{1}{8}$ (4) 2

(5) All suggested answers are incorrect.

PROBLEM B

$$\frac{3}{p} + \frac{3}{q} =$$

(1) $\frac{3(p+q)}{pq}$ (2) $\frac{6}{p+q}$ (3) $\frac{3}{p+q}$

(4) $\frac{3}{pq}$ (5) All suggested answers are incorrect.

PROBLEM C

$$2^{100} + 2^{100} =$$

(1) 2^{200} (2) 4^{100} (3) 4^{200} (4) 2^{101}

(5) All suggested answers are incorrect.

The numerical characteristics of these problems, when they are analyzed, are given in Table 3.

The first column of Table 3 gives the letter designation of the problem used in the illustration. The number following the letter gives the group which was used in analyzing the problem. Group (1) was composed of engineering freshmen who were admitted during 1942 or earlier without entrance examinations on the basis of a satisfactory high school transcript. Group (2) was composed of engineering freshmen who were admitted in September 1948 and who had to pass an entrance examination in addition to submitting a satisfactory high school transcript. Group (3) was composed of students who entered with satisfactory advanced standing and who had to pass, in addition, an entrance examination. Since most of group (3) students were sophomores, it will be referred to as the sophomore group. Group (4) was composed of part time students who were admitted without high school transcripts or entrance examinations, so long as they were not candidates for a degree. They were given a placement examination to ascertain what course in mathematics they might study with a fair degree of success. Usually they were older men with a great deal of ambition to get more education. Fortunately questions A and B happened to appear both on the freshmen entrance examination and on the placement examination, thus shedding some light on some of the problems of adult education.

The column headed 1 gives the per cent of those who attempted the problem and who selected choice No. 1 for the correct answer. Those who omitted the problem were not counted. A similar interpretation is given for the columns headed 2, 3, 4, and 5. For each problem, A, B, and C, column 5 was the choice, "All suggested answers are incorrect," but for none of these three problems was this answer the correct one.

TABLE 3

ANALYSIS OF PROBLEMS A, B, AND C

Problem	1	2	3	4	5	Difficulty	D
A (1)	7	3	89*	1	0	89%	0.14
A (2)	7	2	91*	0	0	91%	0.15
A (4)	11	4	81*	1	2	81%	0.20
B (1)	42*	43	8	2	5	42%	0.77
B (2)	84*	10	3	1	3	84%	0.49
B (3)	97*	2	0	0	0	97%	0.06
B (4)	49*	36	6	1	8	48%	0.65
C (1)	18	46	14	6*	16	6%	
C (3)	13	34	3	24*	25	24%	0.26

* The correct answer.

The column headed "Difficulty" gives the per cent of the group, including those who omitted it, who answered the problem correctly. High numbers are associated with easy problems, whereas low numbers indicate difficult problems. The column headed "D" gives the discriminatory value, D, of the problem.

Analysis of Results

Problem A (1) turned out to be an easy problem for the freshmen of group

(1), 89% of them having answered it correctly. When given to the more selected freshman group (2), it turned out to be slightly easier, since 91% of those freshmen answered it correctly. At the same time, its discriminatory value remained virtually unchanged. Ordinarily Problem A should be rejected; but it turns out to be an excellent problem with which to begin an examination, since it is not so easy as to appear ridiculous, but easy enough to give about 90% of the examinees a good start.

Problem B (1) turned out to be a problem of moderate difficulty for the freshmen of group (1), since 42% of the group answered it correctly. Its discriminatory value of 0.77 makes it an excellent problem to separate the better students from the weaker ones. Problem B (2) illustrates the effect of an entrance examination in preventing weak students from even entering the Institute. Whereas Problem B acted as a question of moderate difficulty with group (1), the same problem became an easy problem for the more selected group (2). At the same time, it still had a good discriminatory value of 0.49. One mislead, No. 4, should be changed, if possible, to a mislead which is more plausible.

Problem B (3) illustrates both the effect of an entrance examination and the screening effect of at least one year in college. Not only has Problem B for the sophomores become too easy, since 97% of them answered it correctly, but it also has now lost its discriminatory power, since D has been reduced to 0.06. Problem B is useless in an entrance examination for college sophomores.

Problem C (1), with a difficulty of 6%, turned out to be too difficult a problem for an entrance examination for freshmen. Its discriminatory power with group (1) unfortunately is not known but must be very small. It should be rejected on an entrance examination for freshmen, unless it is placed at the end of the test and used to select those students from the less than 1% of the population who have real mathematics ability.

Problem C (3), used with sophomores, still remains a difficult problem with the questionable discriminatory ability of 0.26. If the per cent of those who selected the wrong choices of 1, 2, and 3 for group (3) is compared with the corresponding per cents for group (1), it is seen that all three are less. In other words, the sophomores are much less gullible than the freshmen; they have become educated. However, the per cents of those who selected choice No. 5 also shows that the sophomores can think up more wrong answers than the freshmen.

The data in row A (4) and row B (4) show the troubles that instructors experience when teaching part time students, even if they are ambitious. A simple problem like A turned out to be more difficult for the part time students than for the weakest freshmen class. Problem B was only slightly easier for the part time students as compared to the weakest freshmen class, but the high value of D, 0.65, shows that students in the lowest quarter were very poor.

Value of Problem Analysis

An analysis of problems does for an examination what tests do for instruments used by engineers. No engineer would consider the design of a machine complete until he had tested its reliability. No scientist would use a sextant, a stress analyzer, or a balance unless he either knew its reliability or felt that it was a reliable instrument constructed by a responsible firm. Nevertheless, instructors frequently use examinations and base important decisions on them for their students without knowing the reliability and basic characteristics of the tests which they have used. It is true that situations do exist particularly where judgments are based on other considerations than a single test, where it is not necessary for the test to be a first class instrument. However, any test can be improved by determining objectively if a given problem is adapted to the group for which it has been designed through computing its difficulty and by

determining if it is carrying its load through the computation of its discriminatory value. Furthermore, an analysis of test questions sometimes makes it possible to ascertain how far out of line the teaching of a subject is from what it ought to be.

The methods and illustrations which have been given, show not only the need for problem analysis but also how easy such a task really is, and how easy it is to construct a good examination, if a person goes about it in the right way.

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College Notes

Captain John C. Gebhard (C.E.C.), U.S.N., Retired, who supervised the construction of the U. S. Naval Training Center at Sampson, N. Y., and other important, high-speed building projects for the Navy during World War II, has joined the Civil Engineering faculty of **Cornell University.**

New appointments to the Graduate School of **Stevens Institute of Technology** include Wilhelm Ornstein, associate professor at Newark College of Engineering as visiting professor of mechanical engineering; Hans Arnold Panofsky, associate professor at New York University, as visiting professor of meteorology; Gregory H. Wannier, member of the technical staff of Bell Telephone Laboratories, as adjunct associate professor of mathematics and physical science; Marvin Gimprich, consultant at the Stevens Experimental Towing Tank, as adjunct associate professor of fluid dynamics.

Chester A. Arents has been appointed assistant dean of engineering at **Illinois Institute of Technology,** it was announced by Dr. John T. Rettaliata, dean of engineering. Arents has been associate professor of mechanical engineering. He joined the staff in 1947, after serving a year as associate professor at Montana State College. From 1943 to 1946 he was assistant professor at Oregon State College.

The Ohio State University—Wright-Patterson Graduate Center

By S. M. MARCO

Professor of Mechanical Engineering

and C. J. PEIRCE

Professor of Aeronautical Engineering

Ohio State University

Introduction

In order to encourage graduate study and research in engineering, physics, mathematics, chemistry, physiology, economics and related fields, The Ohio State University, in 1946, instituted a Graduate Center at Wright-Patterson Field, Dayton, Ohio, in cooperation with the Air Materiel Command and the Air Force Institute of Technology. The institution and development of this Graduate Center has been carried out under the terms of a contract between the Air Materiel Command and The Ohio State University. This contract has now been in force for more than three calendar years.

The purpose of this Graduate Center, away from the physical boundaries of the University campus, is to provide on-the-job opportunity for qualified personnel of the Air Materiel Command to pursue graduate research and study under university conditions. In principle the Wright-Patterson Graduate Center is considered as an extension of The Ohio State University Graduate School.

Under the terms of the contract the Air Materiel Command provides the necessary funds for the program. The cost of instruction, administration at the Graduate Center, transportation, etc., are charged against these funds. In addition, the students enrolled in the courses pay the regular University fees assessed against part time students in the Twilight School. These fees cover the cost of administration on the University campus.

The Graduate Center is operated under the same rules which apply to the Graduate School on the campus. It is, therefore, directly responsible to the Dean of the Graduate School in regard to academic procedures. Since the program at the Graduate Center is a part time, in-service program, the business details are administered by the Director of the Twilight School on the campus at Columbus.

A full time administrative staff, responsible jointly to the Dean of the Graduate School and the Director of the Twilight School, is maintained at the Graduate Center. It cooperates with the Dean of the Graduate Division of the Air Force Institute of Technology in unifying and supplementing the administration of the program.

The program of each department offering work at the Graduate Center is under the direction of the department chairman or a member of the staff of the department appointed by the chairman.

The Graduate Center Faculty

All members of the Graduate Center Faculty must meet the requirements and have the approval of the Graduate School. These faculty members may be

classified into three categories. First, there are the members of the faculty on the campus. These men, besides being members of the appropriate departmental and college faculties, are also members of the Graduate School faculty. They are selected by the appropriate department to teach and to act as advisors to students in the programs leading to degrees at the Graduate Center. Since this is in addition to their regular University duties, they receive extra compensation for this work.

A second group of members of the faculty are those who are members of the faculty of some neighboring college or university. They are selected by the appropriate Ohio State University department and must meet all of the requirements which that department has for its regular staff members and in addition they must meet the requirements of the Graduate School. These men are employed on a part time basis.

The third group of faculty members consists of qualified employees of one of the laboratories at Wright-Patterson Field. These men are also selected by the appropriate Ohio State University department and must meet the same requirements that are imposed on the two groups previously described. Proper arrangements for their time and compensation are made with their supervisors at the Field.

The problem of securing adequately trained instructors to carry on the program covering numerous fields of specialization has been a difficult one to handle. The instruction, to a large extent, has been handled by The Ohio State University personnel. However, in some instances, it has been necessary to supplement the instructional staff by the procurement of the services of instructors connected with other universities in the vicinity. The distribution of teaching personnel during the Winter Quarter of 1949 reflects this policy as shown herewith:

University or Organization	Number of Instructors
Ohio State University	20
University of Dayton	2
Antioch College	1
Wright-Patterson Field	4
Kettering Foundation	1
Total	28

The selection of courses by individual students following a degree program is entirely under the direction of a regular member of the department responsible for that program. The teaching of classes may be done by any of the staff members previously mentioned. The supervision of research for thesis purposes and examination of candidates for degrees are under the direction of regular members of the appropriate Ohio State University departments.

Registration of Students

Any civilian or military employee of the Air Materiel Command at Wright-Patterson Field who meets the requirements for admission to the Graduate School at Ohio State University is eligible for admission to the Graduate Center. These men follow the same procedure for admission to the program and registration in its courses as is followed by graduate students on the campus. Upon admission to the Graduate School the student is assigned an advisor who helps him to plan his program. If the student is working for a graduate degree he must meet all the requirements for a degree that are imposed upon regular graduate students for retention in the program.

The mechanics of the registration and the fees paid by Graduate Center students are the same as those which apply to Twilight School students on the campus. The student can complete his registration and pay his fees at the Graduate Center so that it is unnecessary for him to go to Columbus for this purpose.

In addition to regular graduate students, the Graduate Center is open to a few advanced undergraduates who may

be admitted to courses which are open to both graduate and advanced undergraduate students on the same basis that they would be admitted to these courses on the University campus. They may register as special students in the appropriate college in the University. They must have a good record and at least a junior standing from an accredited college from which they transfer. The number of such students who are accepted is limited to the number which can be admitted without overcrowding existing courses.

Methods of Instruction

The classes are all taught in the building at Wright Field which houses the Air Force Institute of Technology. The courses carry the same numbers and are taught on the same basis as the corresponding courses on the University campus. They are courses which have been approved for graduate credit on the campus and usually follow the same outline that is followed there.

Classes are scheduled from 3 to 4:30 and from 4:30 to 6 in the afternoon. They are usually alternated each week so that a student who has a 3 to 4:30 class one week will have a 4:30 to 6 class the following week. In this way the student is in class one-half the time on his own time and the other half on his employer's time. Each student may carry up to a maximum of 6 credit hours each quarter. This means that an individual student carries one or two courses each quarter.

Instruction was started at the Wright-Patterson Graduate Center in the Winter Quarter of 1946.

WINTER QUARTER, 1946

Department	*Title*
Mathematics	Advanced Calculus
Electrical Engineering	Network Analysis and Synthesis
Physics	Advanced Electricity

From this beginning with three courses the program has rapidly developed and an indication of the growth can best be given by listing the work given during the Winter Quarter of 1949.

WINTER QUARTER, 1949

Department	*Title*
Aeronautical Engineering	Aircraft Structural Analysis
Aeronautical Engineering	Modern Aircraft Propulsion
Aeronautical Engineering	Missile Ballistics
Aeronautical Engineering	Rotary Wing Theory
Aeronautical Engineering	Mathematical Aeronautics
Business Organization	Business Law—Negotiable Instruments
Chemical Engineering	Chemical Engineering Thermodynamics
Chemical Engineering	Advanced Chem. Eng. Thermodynamics
Chemical Engineering	Chemical Engineering Kinetics
Chemistry	Organic Micro and Semi-Micro Analysis
Chemistry	Colloid Chemistry
Economics	Labor and Government
Economics	Principles of Social Economy
Electrical Engineering	Analysis of Electrical Engineering Problems
Electrical Engineering	Network Analysis and Synthesis
Industrial Engineering	Engineering Economy
Industrial Engineering	Special Problems
Mathematics	Differential Equations
Mathematics	Advanced Calculus
Physics	Modern Atomic Spectroscopy
Physics	Theory of Vibrating Systems
Psychology	Mental and Educational Tests

In addition to the foregoing courses, research courses can be taken in each of the major fields.

Research and Thesis Work

Those students doing research work have regularly scheduled conferences with their advisors. The research work may be carried on in one of the laboratories at the Field. The research topic must be approved by the student's advisor and also by the supervisor of the laboratory in which the student is employed. These subjects in engineering may be experimental, analytical or both. An attempt is made to select a thesis subject closely connected with the work the student is doing in the laboratory in which he is employed. Non-classified subjects are selected if it is possible. If it is necessary to select classified subjects special arrangements have to be made to satisfy the security requirements. The laboratory facilities for research work are extremely good since the various laboratories at the Field are equipped as well as or, in many instances, better than the regular University laboratories.

Library Facilities

The library facilities at the Graduate Center are moderately good. There is the library of the Air Forces Institute of Technology, located in the same building as the Graduate Center, which is available for the use of the students registered in the Center. In addition to this library, the extensive general Wright Field libraries are, with proper restrictions, available for reference work. Another extremely good source of reference material is the large number of reports of research work carried out by outside contractors for the various laboratories at the Field. These reports are usually available at Wright Field long before they are available for general distribution. The contacts made by the students with outside contractors are another fruitful source of information for research reference which is not so readily available to students on the University campus.

Transportation

The problem of transportation of faculty personnel from The Ohio State University campus to the Graduate Center has been handled in several ways. The private cars of the faculty are used, the University car stationed at Don Scott Airport is also utilized and a Beech C-45 seven passenger airplane on loan from the Air Forces has been of value in this connection. The airplane has operated several quarters, making four round trips per week from Don Scott Field to Wright Field. The use of this airplane has resulted in considerable saving of time on the part of the faculty personnel.

Concluding Remarks

It is the opinion of the writers of this paper that the Graduate Center at Wright-Patterson Field is valuable to the students at the Center, to the Air Materiel Command and to The Ohio State University.

The students at the Center are benefiting because they are able to get in-service university training and thus increase their store of knowledge. Furthermore, in a number of cases, they are able to meet the requirements for the master's degree. Thus, these students are able to increase their own competence and, therefore, their value to the Air Materiel Command.

The Air Materiel Command is benefited by this program because of the increased competence of its present personnel. In addition to this it can use the Graduate Center program as an added inducement for attracting and retaining desirable personnel. Another source of benefit to the Air Materiel Command is the contact between its personnel and The Ohio State University faculty members. These contacts have, on a number of occasions, resulted in consultations, with mutual benefits, on problems of re-

search and development being carried on by the Wright-Patterson Field Laboratories.

The Ohio State University benefits because of the relations which its staff members have with the personnel of the Wright-Patterson Field Laboratories. They are brought into contact with research problems which are of mutual interest, and this sometimes means that information on problems in the frontiers of their special fields is made more easily available to them. Because of the special facilities in some of the laboratories, several of these contacts have resulted in research theses which would have been difficult to carry on with the limited facilities of a university.

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A Neglected Technique in Operational Calculus

By C. R. WYLIE, JR.

Chairman, Department of Mathematics, University of Utah

Among the well-known results in Operational Calculus is the following

Theorem: If $f(t)$ is a periodic function with period k, then the LaPlace Transform of $f(t)$ is

$$L(f) = \frac{\int_0^k e^{-st} f(t)\,dt}{1 - e^{-ks}}.$$

This is a useful and completely straightforward formula for transforming any of the various periodic functions of engineering analysis—rectified sine waves, saw tooth waves, or series of Morse dots, for instance.

On the other hand, the inverse problem of determining the function corresponding to a transform whose denominator contains the factor $(1 - e^{-ks})$, as well as other, purely algebraic factors, seems to be nowhere near as well standardized. McLachlan (1), for instance, solves the problem through the use of the inversion integral and the theory of residues. Gardner and Barnes (2) suggest two methods, one based on the Mittag-Leffler partial fraction theorem, the other on the expansion of the factor $\frac{1}{1 - e^{-ks}}$ in an infinite series of powers of e^{-ks}. Churchill (3) employs the latter process and also an equivalent method based on the convolution integral.

In connection with this expansion procedure (which seems to be the most elementary and natural one) it does not appear to be well known that its results, in all cases of practical interest at least, can be put in a simple, finite form. The purpose of this note is to indicate how this can be done, and to present a short list of such forms in terms of which the inverse of any transform containing $\frac{1}{1 \pm e^{-ks}}$ can be expressed. The manipulations are essentially elementary, and we shall not go into extensive mathematical detail in our exposition. The derivation of one typical formula and the discussion of an example should enable us to say legitimately that the rest "can be left as an exercise for the student."

Suppose, then, that at the penultimate stage in a problem we have the information that the transform of the function we are seeking is

$$F(s) \cdot \frac{1}{1 \pm e^{-ks}},$$

where the denominator of $F(s)$ is assumed to consist solely of real linear and irreducible quadratic factors. If we expand the factor $(1 \pm e^{-ks})^{-1}$ in a series in e^{-ks} we obtain for the transform

$$F(s)(1 \mp e^{-ks} + e^{-2ks} \mp e^{-3ks} + e^{-4ks} \cdots).$$

Now let $g(t)$ be the function of t having $F(s)$ for its LaPlace transform. Under the above assumption regarding $F(s)$ the determination of $g(t)$ presents no problem.

The complete inverse, by the well-known theorem on real translation, can now be written

$$f(t) = \sum_{j=0}^{\infty}(-1)^j g(t - jk)u(t - jk),$$

where $u(t)$ is the familiar unit step function.

For any value of t the above expression for $f(t)$ is clearly a finite sum. Moreover, and this is the neglected technique to which we wish to call attention, this finite series can always be explicitly summed. In fact if the denominator of $F(s)$ contains no repeated factors, $g(t)$ can contain only terms of the form $u(t)$, e^{-at}, $e^{-at}\sin bt$, and $e^{-at}\cos bt$, all of which can be included in the one form e^{-at} if a be permitted to assume complex values. But a series of the form

$$e^{-at} \mp e^{-a(t-k)} + e^{-a(t-2k)} \mp e^{-a(t-3k)} \cdots (\mp 1)^n e^{-a(t-nk)}$$

is just a geometric progression whose sum it is an easy matter to write down and convert to a purely real form.

On the other hand, if the denominator of $F(s)$ contains repeated factors then the typical terms noted above as possibilities can also occur multiplied by powers of t. In this case the general term of the sum which we must consider is of the form $t^c e^{-at}$. Now a series of the form

$$t^c e^{-at} \mp (t - k)^c e^{-a(t-k)} + (t - 2k)^c e^{-a(t-2k)} \cdots (\mp 1)^n (t - nk)^c e^{-a(t-nk)}$$

while clearly not a geometric progression can still be explicitly summed. In fact from the Calculus of Finite Differences, we have the following

Theorem (4): If α be any constant, real or complex, $\phi(j)$ a polynomial of order m, and if $\beta = \dfrac{\alpha}{\alpha - 1}$, then

$$\sum_{j=0}^{n}\alpha^j\phi(j) \equiv \phi(0) + \alpha\phi(1) + \cdots \alpha^n\phi(n)$$

is equal to

$$\alpha^j V(j)\Big]_{j=0}^{j=n+1} = \alpha^{n+1}V(n + 1) - V(0),$$

where

$$V(j) = \frac{1}{\alpha - 1}\{1 - \beta\Delta + \beta^2\Delta^2 \cdots (-1)^m\beta^m\Delta^m\}\phi(j)$$

and Δ is the ordinary difference operator defined by the properties

$$\begin{aligned}\Delta f(j) &= f(j + 1) - f(j)\\ \Delta^2 f(j) &= \Delta f(j + 1) - \Delta f(j)\\ &\cdots\end{aligned}$$

This serves to sum the series, following which it is an easy matter to convert the complex exponentials, if any, into a purely real form.

As a sample derivation, let us find

$$f(t) = L^{-1}\left\{\frac{1}{(s + a)^2(1 + e^{-ks})}\right\}.$$

In this case $F(s)$ is $\dfrac{1}{(s + a)^2}$; hence $g(t) = te^{-at}$. Then fixing our attention on a

general period, say $nk \leqq t \leqq (n+1)k$, we have for $f(t)$ over this interval

$$\sum_{j=0}^{n}(-1)^j(t-jk)e^{-a(t-jk)} \equiv e^{-at}\sum_{j=0}^{n}(t-jk)(-e^{ak})^j.$$

Applying the summation method of the above theorem, we make the following identifications:

$$\alpha = (-e^{ak}), \qquad \beta = \frac{-e^{ak}}{-e^{ak}-1} = \frac{e^{ak}}{e^{ak}+1}, \qquad \phi(j) = (t-jk), \qquad m = 1,$$

$$V(j) = \frac{1}{-e^{ak}-1}\left\{1 - \frac{e^{ak}}{e^{ak}+1}\Delta\right\}(t-jk) = \frac{-1}{e^{ak}+1}\left\{(t-jk) + \frac{ke^{ak}}{e^{ak}+1}\right\}.$$

The required sum is therefore

$$e^{-at}\left[V(j)(-e^{ak})^j\right]_{j=0}^{j=n+1}$$

$$= e^{-at}\left[\frac{-1}{e^{ak}+1}\left\{t - \overline{n+1}k + \frac{ke^{ak}}{e^{ak}+1}\right\}\left\{-e^{ak}\right\}^{n+1}\right] - e^{-at}\left[\frac{-1}{e^{ak}+1}\left\{t + \frac{ke^{ak}}{e^{ak}+1}\right\}\right]$$

$$= (-1)^n e^{-a(t-\overline{n+1}k)}\frac{(t-\overline{n+1}k)(e^{ak}+1)+ke^{ak}}{(e^{ak}+1)^2} + e^{-at}\frac{t(e^{ak}+1)+ke^{ak}}{(e^{ak}+1)^2}$$

TABLE I

DEFINITIONS FOR $nk \leqq x \leqq \overline{n+1}\,k$

1.	ss(x, k) 'staircase function'	$\equiv$	$n+1$
2.	md(x, k) 'Morse dot function'	$\equiv$	$\dfrac{(-1)^n+1}{2}$
3.	rss(x, k)	$\equiv$	$(n+1)x - \dfrac{n(n+1)k}{2}$
4.	rmd(x, k)	$\equiv$	$\dfrac{(-1)^n+1}{2}x + \dfrac{k}{4}\{1-(-1)^n(2n+1)\}$
5.1	epi(x, a, k)	$\equiv$	$\dfrac{e^{-ax}}{e^{ak}-1}$
5.2	epi$_1(x, a, k)$	$\equiv$	$\dfrac{e^{-ax}}{e^{ak}+1}$
6.1	cpi(x, a, b, k)	$\equiv$	$\dfrac{e^{-ax}\cos b(x+k) - e^{-a(x+k)}\cos bx}{2(\cosh ak - \cos bk)}$
6.2	cpi$_1(x, a, b, k)$	$\equiv$	$\dfrac{e^{-ax}\cos b(x+k) + e^{-a(x+k)}\cos bx}{2(\cosh ak + \cos bk)}$
7.1	spi(x, a, b, k)	$\equiv$	$\dfrac{e^{-ax}\sin b(x+k) - e^{-a(x+k)}\sin bx}{2(\cosh ak - \cos bk)}$
7.2	spi$_1(x, a, b, k)$	$\equiv$	$\dfrac{e^{-ax}\sin b(x+k) + e^{-a(x+k)}\sin bx}{2(\cosh ak + \cos bk)}$
8.1	repi(x, a, k)	$\equiv$	$\dfrac{(x+k)e^{-ax} - xe^{-a(x+k)}}{2(\cosh ak - 1)}$
8.2	repi$_1(x, a, k)$	$\equiv$	$\dfrac{(x+k)e^{-ax} + xe^{-a(x+k)}}{2(\cosh ak - 1)}$

TABLE II

	LaPlace transform	Function ($-k \leqq \tau \leqq 0$, $nk \leqq t \leqq \overline{n+1}\,k$)
1.	$\frac{1}{s(1-e^{-ks})}$	$\mathrm{ss}(x, k)$
2.	$\frac{1}{s(1+e^{-ks})}$	$\mathrm{md}(x, k)$
3.	$\frac{1}{s^2(1-e^{-ks})}$	$\mathrm{rss}(x, k)$
4.	$\frac{1}{s^2(1+e^{-ks})}$	$\mathrm{rmd}(x, k)$
5.1	$\frac{1}{(s+a)(1-e^{-ks})}$	$\mathrm{epi}(\tau, a, k) - \mathrm{epi}(t, a, k)$
5.2	$\frac{1}{(s+a)(1+e^{-ks})}$	$(-1)^n \mathrm{epi}_1(\tau, a, k) + \mathrm{epi}_1(t, a, k)$
6.1	$\frac{s+a}{(s+a)^2+b^2)(1-e^{-ks})}$	$\mathrm{cpi}(\tau, a, b, k) - \mathrm{cpi}(t, a, b, k)$
6.2	$\frac{s+a}{(s+a)^2+b^2)(1+e^{-ks})}$	$(-1)^n \mathrm{cpi}_1(\tau, a, b, k) + \mathrm{cpi}_1(t, a, b, k)$
7.1	$\frac{b}{(s+a)^2+b^2)(1-e^{-ks})}$	$\mathrm{spi}(\tau, a, b, k) - \mathrm{spi}(t, a, b, k)$
7.2	$\frac{b}{(s+a^2+b^2)(1+e^{-ks})}$	$(-1)^n \mathrm{spi}_1(\tau, a, b, k) + \mathrm{spi}_1(t, a, b, k)$
8.1	$\frac{1}{(s+a)^2(1-e^{-ks})}$	$\mathrm{repi}(\tau, a, k) - \mathrm{repi}(t, a, k)$
8.2	$\frac{1}{(s+a)^2(1+e^{-ks})}$	$(-1)^n \mathrm{repi}_1(\tau, a, k) + \mathrm{repi}_1(t, a, k)$

or, dividing the top and bottom of each fraction by e^{ak},

$$(-1)^n e^{-a(t-\overline{n+1}k)} \frac{(t-\overline{n+1}k)(1+e^{-ak})+k}{2(\cosh ak+1)} + e^{-at}\frac{t(1+e^{-ak})+k}{2(\cosh ak+1)}.$$

The second fraction is clearly independent of n, i.e. is of the same structure in all periods. Because of the factor e^{-at} it is of negligible importance after the first few periods.

To achieve a more symmetric form, let us write $\tau = t - \overline{n+1}k$ in the first fraction. The variable τ thus ranges from $-k$ to 0 as t ranges from nk to $\overline{n+1}k$ Then the above function becomes

$$(-1)^n e^{-a\tau}\frac{\tau(1+e^{-ak})+k}{2(\cosh ak+1)} + e^{-at}\frac{t(1+e^{-ak})+k}{2(\cosh ak+1)}$$

or, rearranging slightly,

$$(-1)^n \frac{(\tau+k)e^{-a\tau}+\tau e^{-a(\tau+k)}}{2(\cosh ak+1)} + \frac{(t+k)e^{-at}+te^{-(at+k)}}{2(\cosh ak+1)}.$$

The first of these fractions yields the same set of values, except for the alternating sign, in all periods. It is therefore the steady-state portion of the inverse.

Without further proof we shall now list additional forms, analogous to the one just derived, in terms of which the inverse of $F(s)\dfrac{1}{1 \pm e^{-ks}}$ (after $F(s)$ has been broken down into partial fractions) can be expressed. To do this conveniently we shall coin a number of functional symbols to describe compactly the combinations of elementary functions to which we shall refer. In each case the notation is at least mildly suggestive. Thus the letters *pi* suggest 'periodic inverse.' The letters *e*, *c*, *s* suggest respectively 'exponential,' 'cosine,' and 'sine.' The letter *r* suggests the adjective 'repeated.' Functional titles without subscripts identify functions associated with LaPlace transforms containing the customary factor $\dfrac{1}{1 - e^{-ks}}$. The subscript 1 identifies a function associated with an *L*-transform containing $\dfrac{1}{1 + e^{-ks}}$.

The transient components (*t*-evaluated components) of all inverses are continuous for all $t > 0$. This is true of the steady state terms (τ-evaluated components) of the inverses only if the order of the denominator of $F(s)$ exceeds by more than one the order of the numerator. When the order of the denominator of $F(s)$ is exactly one more than the order of the numerator there is a 'jump' of $+1$ in the steady state term in crossing each of the period boundaries, $t = nk$, if the associated transform contains $\dfrac{1}{1 - e^{-ks}}$; and a 'jump' of $(-1)^n$ in crossing each period boundary if the associated transform contains $\dfrac{1}{1 + e^{-ks}}$.

Example

A simple series circuit contains the parameters $R = 400$, $L = .2$, $C = 10^{-6}$. At $t = 0$, while the circuit is completely passive, an exponential sawtooth e.m.f. equal to E_0e^{-5000t} throughout one period, and repeating itself every .002 seconds, is switched into the circuit. Find the total response of the circuit and also the steady state behavior.

The differential equation to be solved is

$$.2\frac{di}{dt} + 400i + 10^6\int_0^t i\,dt = E(t).$$

Taking the *L*-transform of this equation we have

$$L(i)\left(.2s + 400 + \frac{10^6}{s}\right) = \frac{E_0\int_0^{\pi\delta\sigma} e^{-st}e^{-5000t}dt}{1 - e^{-s/500}} = E_0\frac{1 - e^{-5000+s/500}}{(1 - e^{-s/500})(s + 5000)}$$

$$= \frac{E_0e^{-10}}{s + 5000} + \frac{E_0(1 - e^{-10})}{(s + 5000)(1 - e^{-s/500})};$$

$$\therefore\quad L(i) = \frac{5E_0(1 - e^{-10})s}{(s + 5000)\overline{(s + 1000^2 + 2000^2)}(1 - e^{-s/500})}$$

$$+ \frac{5e^{-10}E_0s}{(s + 5000)\overline{(s + 1000^2 + 2000^2)}}.$$

Now by familiar partial fraction manipulations we have

$$\frac{s}{(s+5000)\overline{(s+1000^2+2000^2)}} = \frac{1}{4000}\left\{\frac{-1}{s+5000} + \frac{s+1000}{\overline{s+1000^2+2000^2}}\right\}.$$

From this point the entire solution can be written down at once:

$$i = \frac{5E_0e^{-10}}{4000}\{-e^{-5000t} + e^{-1000t}\cos 2000t\}$$
$$+ \frac{5E_0(1-e^{-10})}{4000}\left\{\mathrm{cpi}\left(\tau, 1000, 2000, \frac{1}{500}\right) - \mathrm{cpi}\left(t, 1000, 2000, \frac{1}{500}\right)\right\}$$
$$- \frac{5E_0(1-e^{-10})}{4000}\left\{\mathrm{epi}\left(\tau, 5000, \frac{1}{500}\right) - \mathrm{epi}\left(t, 5000, \frac{1}{500}\right)\right\}.$$

The steady state is described by the terms in τ:

$$i_{ss} = \frac{5E_0(1-e^{-10})}{4000}\left\{\mathrm{cpi}\left(\tau, 1000, 2000, \frac{1}{500}\right) - \mathrm{epi}\left(\tau, 5000, \frac{1}{500}\right)\right\}$$

or, written out at length,

$$i_{ss} = \frac{5E_0(1-e^{-10})}{4000}\left\{\frac{e^{-1000\tau}\cos 2000\left(\tau+\frac{1}{500}\right) - e^{-1000(\tau+1/500)}\cos 2000\tau}{2(\cosh 2 - \cos 4)} - \frac{e^{-5000\tau}}{e^{10}-1}\right\}.$$

This function, plotted for $\frac{-1}{500} \leq \tau \leq 0$, defines one complete cycle of the steady state behavior. Of course the unit 'jumps' in $\mathrm{cpi}(\tau)$ and $-\mathrm{epi}(\tau)$ at the ends of each period just cancel, leaving the steady state function continuous, as of course it must be.

References

1. McLachlan, N. W.: "Modern Operational Calculus," p. 136.
2. Gardner, S. M., and Barnes, J. L.: Transients in Linear Circuits," p. 240.
3. Churchill, R. V.: "Modern Operational Mathematics in Engineering," p. 93.
4. Milne-Thompson, L. M.: "The Calculus of Finite Differences," p. 46.

Teaching Elementary Column Theory

By PHILIP K. ROOS

Associate Professor of Engineering Mechanics, Pennsylvania State College

The derivation of the Euler equation is often a first step in the teaching of columns. This basic form can be derived by the same moment-area method which proves such a useful tool in the calculation of deflections in flexural members. Its application to columns has been noted by Professor Van Den Broek in his book on limit design and Professors Sutherland and Bowman in their text on structural design. This use is based on the assumption that the deflection curve and the moment diagram for the column, as the axial load approaches a critical value, are both sine curves.

The first step in the use of this method is to point out to the student, with illustrations, that he knows the areas and centroids of many geometric figures in terms of certain constants and the intercepts the figures make with the coordinate axes. Then set him the problem of finding the constants that will give him the area and centroid of the sine curve between 0° and 90° when the intercepts on the x and y axes are in the general terms b and a instead of the specific $\pi/2$ and 1. The expression for area will turn out to be $A = \frac{2}{\pi}ab$, and for centroidal distance along the x axes measured from 0°, $\bar{x} = \frac{2}{\pi}b$.

When this is done, the deflected shape of a pinned-end, axially loaded column of length L and load P can be studied to see how Theorem II of the moment-area principles can be applied to find the maximum deflection Δ of the column. Then the moment diagram, which is a sine curve with a length L and a maximum ordinate or moment of $P\Delta$, should be drawn. In the general expression for the maximum deflection $EI\Delta = A\bar{x}$, A will be equal to $\frac{P\Delta L}{\pi}$ and $\bar{x}$ will be equal to $\frac{L}{\pi}$. The general expression then reduces to the Euler expression for the critical buckling load $P = \frac{\pi^2 EI}{L^2}$.

In some texts the general case considered is the column fixed at one end and free at the other end with a length L and a load P at the free end. In this case, $\bar{x} = \frac{2L}{\pi}$, $A = \frac{2P\Delta L}{\pi}$ and the expression for the critical load becomes $P = \frac{\pi^2 EI}{4L^2}$. Other conditions of fixed and pinned-end columns are then considered as being made up of some multiple of this general case. These cases are well known and they are recalled here only to indicate the variety of ways this problem can be treated by the moment-area method.

From the viewpoint of engineering education in general, it is important that the students be disabused of any ideas that this is a means of circumventing a mathematical analysis. The form of the differential equation involved can be used to show the student the reason for the basic assumptions. It can thus be shown that a sound basic understanding of mathematics is needed to appreciate when and how a graphical method may be applied.

Co-operative Standards and Criteria*

By JOHN M. HOUCHENS

Associate Professor of Co-ordination, University of Louisville

Because of the shifting emphasis on the relative importance of professional, social, and economic factors, it has become imperative that we re-study the objectives and standards for our various co-operative plans. If we are to do a good job in the co-operative schools in training our students to render effective and efficient service in the engineering profession, the criteria by which we measure the organization and operation of our programs must be sound and adequate.

Dean Freund and his committee on Aims and Ideals of Co-operative Engineering Education did an excellent job in organizing the collective thinking on these matters into the [1] report presented to this society two years ago. It has served as a good basis and an inspiring stimulus for each of us in studying our respective programs.

The writer is presenting some of his observations and thoughts on the matter of standards and criteria as derived from his experiences with the program at the University of Louisville.

It has been an inspiration to note during the post-war re-organization period the soundness of the basic principle of the co-operative system for training young men for their most effective performance in the engineering profession. It is strongly indicated that the co-operative method has an expanded and enhanced significance in this period when the world is so keenly aware of the sociological and economic import of the engineer and his work. Since the achievements of engineers so vitally affect every phase of human existence and activity, it is imperative that they not only have some concept of all the other factors of civilization but also that they learn to organize and apply their knowledge and skill so as to contribute most to the welfare of humanity. Engineers must become more and more a part of the world they so profoundly shape. Engineers can be isolationists no longer without contributing to the detriment and decline of civilization. The co-operative system offers unusual opportunity to introduce this viewpoint to students.

Objectives of Co-operative System

The writer has formulated the following summary of objectives of the co-operative system as a basis for our study and discussion:

1. To provide an opportunity for the student to obtain a clear concept of engineering and to determine whether he is adapted to the profession and to the branch he has chosen.

2. To give the student a background of practical experience under actual industrial conditions: first, in order to help him comprehend more readily the basic principles taught in the various courses and to cause him to appreciate more fully their applications to useful processes and real problems. The second phase of this objective of practical experience is to introduce the student to the methods and techniques of the appli-

* Presented at the Co-operative Engineering Education Division at the Annual Meeting, Austin, Texas, June 14, 1948.

[1] *Proceedings* of the American Society for Engineering Education, vol. liv, p. 117.

cation of engineering principles, *i.e.*, "the engineering know how."

3. To give the student an understanding of the human factors in the industrial and professional world; and to help him develop his personality and tact so that he can deal successfully with the various types of people he must associate and work with in his professional career.

4. To acquaint the student with the economic factors of engineering and industry, particularly the relative value of time, money, and materials.

5. To train the student to meet industrial and professional discipline and demands.

6. To give the student a comprehension of human values and relationships; and to create in him a consciousness and a perspective of his responsibilities to society as a citizen and as an engineer.

It should be borne in mind and constantly emphasized to all concerned—faculty, employers, and students—that the co-operative system is first and foremost an educational program closely integrated with the course work at school and designed to train the student in all the factors involved in the profession.

It is easy and tempting, especially for students, to emphasize some of the incidental values of the co-operative system rather than the main objectives. Especially is this true with respect to the values of making money and the establishing of connections which will be useful in securing employment after graduation. All of us recognize the worth of these and the other incidental values of the co-operative system in their proper relationship and perspective to the ultimate objectives of the program.

Analysis of Objectives

Let us now examine the six principal objectives outlined above.

In accord with item one, the co-operative system introduces the realities of applied engineering and its demands clearly and forcefully to the students early in their careers. It emphasizes to each one all factors, in addition to technical knowledge which are necessary for success in the profession—personality, industry, leadership, initiative, and many others.

We are recognizing more and more that the ability to pursue successfully the academic curricula of an engineering course does not necessarily indicate that a student has all the qualities prerequisite for success in the profession. The co-operative system helps the students themselves, with counsel of the faculty and the employers, to discover their strengths and their weaknesses. With the clearer concepts gained on co-operative work the students should proceed in their courses with more confidence and effectiveness.

As indicated in item two the practical experience of working with and observing the application of scientific principles does much to help students understand the principles already studied in the courses as well as those studied after the experience.

Somewhere in his career the successful engineer must become familiar with the methods and techniques—"the know how"—of the profession. He must learn how to apply the knowledge and principles effectively and efficiently. He cannot learn very much in a short co-operative work period. However, the practical experience of co-operative employment offers him an opportunity to acquire some of the rudiments and concepts of this all important phase of his chosen field.

The objective of having the co-operative student learn the factors and principles involved in getting along with people and in supervising them, as stated in item three, is particularly important because most engineering graduates eventually become administrators and executives. Of course, the co-operative system cannot infuse the innate qualities of leadership. It can, however, help students discover the demands in this field and inspire them to develop their own personalities, attitudes, and techniques accordingly.

To the engineer, the matter of controlling costs in order to make his achieve-

ments practicable and to meet competition successfully has long been a vital factor. Hence item four. Properly planned co-operative programs should emphasize to the students the opportunity to observe the basic principles of cost control as established and practiced by successful industrial and engineering organizations.

Item five recognizes the necessity for self discipline in any vocation. Regardless of his other qualities, an engineer's general attitude, his personal habits, his initiative, his industry, his method of thinking, his thoroughness, his accuracy, and many other such characteristics will play a large role in his success or failure.

With respect to item six, the significance of engineering achievements to the economic, political, and sociological phases of our civilization has already been indicated and stressed in this paper. Likewise the resulting importance that engineers consider these factors in their work and also, participate more actively as citizens in working out the problems has been emphasized. The writer believes that the co-operative system offers a splendid opportunity for the student to recognize the importance of this viewpoint and to develop his thinking along these lines.

Criteria For Success of Co-operative Program

In order for any co-operative plan to be successful in achieving its objectives, it must have certain well defined criteria by which to measure its organization and operation. The following items are presented without much elaboration for our consideration:

1. The basic principles of the co-operative system should be heartily endorsed and actively supported by the administration and faculty of the school.

2. The co-operative plan should be integrated closely with the basic curricula and program of the school in order that all phases of a student's training shall contribute to the ultimate objectives of the course as a whole. In no case should the co-operative work be considered as a separate part of the school's program.

One of the best ways of achieving this co-ordination is through a co-operative work committee consisting of representatives of the administration, the degree granting departments, and the co-ordination department. Such a committee serves in an advisory capacity to the co-ordinators in establishing policies, in evaluating co-operative jobs for their educational value, in selecting students for the respective jobs, and in evaluating the students' experiences.

3. It is particularly important that the executives and the supervisory personnel of co-operating firms understand and endorse the basic objectives of the co-operative system as an educational program. A school must of necessity depend largely on the employer to contribute to the achievement of the objectives.

4. With the co-operation of the employer and the counsel of the co-operative committee, employment programs should be arranged so that each student will obtain the maximum benefit possible with respect to the objectives.

5. It is necessary that the students be made familiar with the concepts and objectives of the co-operative system. Also, they must be effectively inspired to make the most of their experiences and opportunities with respect to the main objectives as well as to the incidental advantages of the system. Hence, the co-ordinators must be on the job continuously.

6. As in plans and programs of all sorts the success of the co-operative system is largely dependent upon those who administer it. The intelligence, general attitude, initiative, and industry of the co-ordinators and their ability to inspire students will determine mostly the effectiveness of any co-operative plan. The work is arduous and requires constant alertness. Problems constantly arise which continually call for ingenuity, diplomacy, and patience. It is easy to see that co-ordinators must be selected with much care.

The co-operative system is designed pri-

marily for the benefit of the students. However, it is not magical; it does not deliver benefits automatically. The system, when properly organized and administered, merely offers an opportunity for development. As in all educational programs the values derived depend mostly upon the student's attitude and industry. If he profits by his co-operative experience, he must work hard; observe things, conditions, and people closely; interpret observations and experiences wisely; formulate sound philosophies; and make people like him. The responsibility and the challenge to every co-operative school is to so organize and administer its plan as to lead and inspire its students to do these things.

Conference on Administration of Research

The Third Annual Conference on the Administration of Research was held at The Pennsylvania State College September 12, 13 and 14, with the following papers being presented:

"University Research and What to Do About It," S. Tour;
"Advancement of Basic Knowledge," F. C. Lindvall;
"Functions of University Research from the Viewpoint of Government," H. L. Dryden;
"Functions of Sponsored University Research," L. A. Hyland;
"Dissemination of Results of University Research," C. G. King;
"Patent Policies," A. M. Palmer;
"Methods for Evaluation of Research," F. Olsen;
"Summary," E. A. Walker.

The "Proceedings" of the Conference will be available approximately February 1, 1950, at a cost of $3.00 per copy. Copies may be obtained by addressing Professor K. L. Holderman at Engineering Extension, Pennsylvania State College, State College, Pennsylvania. Although "Proceedings" of the First Conference are now out of print, there are available a few copies of the Second Conference "Proceedings" at this price.

The Place of the Technical Institute School Graduate in Industry*

By JOHN A. LUNN

Vice President, Dewey and Almy Chemical Co.

This subject is of particular interest and significance to me, first, because of my association a number of years ago in a teaching capacity with a technical institute, and secondly, because of my opportunity to observe the work and accomplishments of many graduates of these institutes in manufacturing establishments and other business institutions. In order to appraise and measure our subject properly, it seems important to me to develop some observations concerning the evolution of our industrial pattern, the changes in our technical education and their respective impacts upon each other.

We need only to go back to the turn of the century to visualize the tremendous industrial changes which have taken place. We have heard references in the public and technical press to the "Mechanical Age"; to "Electricity, The Public Servant"; to "Better Things for Better Living through Chemistry." For the purposes of my discussion, I should like to divide this period into three phases or cycles. Time permits only a very brief comment on these phases.

I. *Mechanization and Tooling Up*

The development of the Automotive Industry is one of the best examples of this period. The impacts of this development were far reaching—foundry practice, sheet steel production, electrical equipment, machine tool development, steel drawing and fabrication, rubber production and manufacture, petroleum refining, and many other large industries were affected by this gigantic development.

II. *Development and Utilization of Efficiency Systems*

Here we can include Taylor and Bedeaux and literally thousands of others. They all served the useful purpose of making industry more conscious of personal productivity. Hundreds of incentive and bonus plans resulted from these systems.

III. *Organized Industrial Research*

Industrial research is here to stay. Industry relies on research to develop new processes and products, to eliminate waste, to develop useful by-products, to produce higher yields and to obtain lower costs.

In addition to these more or less normal developments in the industrial cycle, we have had the violent impact of two World Wars during this period, which had a result much farther reaching than the actual duration of hostilities.

Each of the above factors has had its definite effect on industry's requirements for technically trained men. It is not surprising that American Industry, in practically all of its branches, finds itself understaffed with technical men. Consequently every foreman, supervisor, superintendent, draftsman, designer, and engineer has more rigorous demands upon his judgment, his ability to carry responsibility, to make decisions, to teach and train others, to think and work under pressure.

* Presented before the Technical Institute Division of the New England Section, ASEE, Boston, Mass., October 16, 1948.

Educational Changes

Now let us consider briefly some of the educational changes which have taken place during these periods. The increase in the number of our high school graduates during the last 25 years has been at a rate which is 13 times as great as our increase in population. Consequently, we find today that almost every position involving any responsibility is filled by those having at *least* a high school education. We also find a large proportion of hourly rated jobs filled by high school graduates.

Almost every first rate high school has a Department of Vocational Education, or at least a Counsel for Vocational Guidance. Many *Technical* High Schools give courses in elementary Applied Mechanics, Chemistry, Physics, Electricity, Radio, and Machine Tool Work.

Then we have the trade schools which in general contribute more to the man at the bench and to craftsmen than to those training for supervisory capacities. These opportunity schools augment the training of many who may not have had a high school education. In most of these schools the teaching is of an entirely practical nature for a specific job. Trade schools covering substantialy similar ground are to be found in Great Britain and Germany.

Place of the Technical Institute

The technical institute as we know it in the United States has for its purpose the training of people for positions which occupy an area between the skilled crafts and the highly scientific professions. In Europe we find a number of institutions with kindred objectives: The National Schools of Industrial Arts in France, the higher industrial schools in Germany, The Technical Gymnasia in Sweden, The Technicums in Switzerland, and the so-called local technical institutions in Great Britain.

It is the method of operation of the technical institute in our country and its freedom from narrow regimentation which have made it a significant and vital factor in our educational pattern. It has put technical education within the reach of almost everyone who is willing to work for it. It has helped to make education in the United States a truly democratic force. It has met the challenge of two wars within a single generation and has carried its share of the burden of technical training both during and after these emergencies. Its physical equipment has steadily improved and its educational standards have grown constantly stronger during this period of industrial development.

The primary goal of the technical institute is to serve industries by giving them trained men who can accept and carry the responsibility connected with industrial development. In this connection, I was very much impressed with a chart which has just been prepared and shows graphically the semester hours by subjects which are required for a chemistry major by a technical institute and 5 colleges and engineering degree schools in this area. The requirements of the technical institute compared very favorably with those of the degree institutions. Thus the technical school graduate has been given many new and important tools with which to accomplish the above objective. While the lack of a degree presents a theoretical handicap for some industrial positions, the openings which are waiting for the technical school graduate are literally legion.

Let us enumerate some of them:

Production

Foremen
Supervisors
Superintendents
Production Engineers
Production Planning
Time Study Men
Job Analysis
Inspectors
Quality Control
Laboratory Control
Analytical Laboratory Work
Physical Testing
Inventory Control
Receiving and Shipping

Engineering

Draftsmen
Machine Designers
Equipment Layout
Construction
Power Plant
Maintenance
Efficiency Engineering
Safety Engineers
Master Mechanics
Sales and Service Engineers

In addition, there are many opportunies in other branches of business for the technical school graduate, in purchasing, in industrial relations, in expediting, in traffic management, in sales of technical products, and in a host of other departments.

On the other hand, there are some industrial positions which generally are not open to graduates of the technical school because of very specialized requirements. Here we might include Chemical and Physical Research, Accounting, Tax Work, Legal, Budgeting, Financial, Advertising, Sales Promotion, and the like.

Now let us try to measure the extent to which the technical school graduate is filling this potential. A survey of the positions held by the 1948 graduating class of 305 from a leading technical institute in this area showed the following distribution of its graduates:

20%—In positions allied to their specific training
16%—Drafting, Layout and Design (Mechanical and Architectural)
13%—Miscellaneous
12%—Engineering and Laboratory Assistants
10%—In business for self or with father
8%—Machinists (some doing experimental work)
5%—Pattern-makers and Assistants
4%—Aircraft Mechanics
3%—Carpenters
2%—Teaching
2%—Plant Engineers Assistants
2%—Sales work
2%—In training for Industrial Plant Managers
1%—Obtaining Higher Education

Among graduates of technical institutes may be found Draftsmen, Machine Designers, Machinists, Tool and Die Makers, Engineers, Plant Engineers, Teachers, Superintendents, Salesmen, Insurance and Building Inspectors, Foremen, Sales Managers, Electricians, Production Managers, Contractors, Builders, Architects, Carpenters, Pattern-makers, Manufacturers and many others too extensive to mention.

I think we can conclude that the technical institutes are measuring up to their opportnuity in placing their graduates in important and diverse industrial jobs.

Unfortunately time does not permit us to discuss the training offered by the engineering colleges, universities and technical institutions which confer degrees and the extent to which their graduates may be in competition with the technical school graduate. I am reminded of a remark made by a Professor of English in his opening lecture to freshmen in a leading technical institution, which confers both Bachlors and Advanced Degrees—"Gentlemen, this institution has ruined a lot of fine plumbers." If this observation is true, some of this competition may not be of the highest order.

The President's Commission on higher education has reported that the quantitative demand for technical institute graduates is more than 5 times the need for graduates of four-year engineering schools. This is a very significant finding and should prove to be an effective catalyst to the technical institute and its graduate.

An excellent job has been done also by those institutions offering courses which cooperate with industry. This type of basic training has brought industry and education much closer together and has given each a more tolerant appreciation of the other's problems.

In closing, let me state that the technical institute school is carrying its full share of the educational load. Because of the breadth of its base in recruiting students, it is inevitable that some will fall by the wayside, both during their edu-

cational period and when they meet the rigorous requirements of industry. Some will not get immediate recognition but will have to prove themselves on the job. Those who ultimately succeed, however, are hard to dislodge because they are in dead earnest, because they have had sound, basic, practical training and have worked for it every step of the way. Industry relies heavily on such men for a large and important segment of its technical and supervisory organization.

To those of you who have the guidance and teaching of these men, we can only say—continue that objective training program. Train them to be doers. Give them an even greater appreciation of human values and human relations. Teach them *how* to teach others; in a word, *keep up* the good work.

ANNUAL MEETING

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Teacher Qualifications in Relation to Education Outside the Classroom*

By WILLIAM E. RANZ

Proctor and Gamble Fellow, Department of Chemical Engineering, University of Wisconsin

In technical education a major controversy of the young student with his training is a spiritual one; and because such an aspect of human behavior seems illusive to technical people, it has not received much attention from modern educators. Consequently, if you seek the student's ideas about his teachers, you will not obtain a lucid, clear-cut answer. His feelings toward his education are more instinct than thought and more heart than mind.

For example, consider a case history.

This man is a mass-produced graduate of a large university. He is a successful young engineer, but he remembers his undergraduate preparation with some bitterness. His grounding in class-room logic, in facts and figures, in forthright scientific and industrial knowledge was in the main a superb foundation upon which to build his later economic success, but he found the process deadly dull and dry as powder. He does not know why the notices of class reunions go into the waste basket with hardly a glance and absolutely no nostalgic twinge of memory, but he is suspicious of the overall merit of his education and has decreed that his son will go to a small school and will not study engineering.

This man was attracted to an engineering education for several reasons. He possessed unusual talents in mathematics and science. He approved of the skeptical, take-nothing-for-granted attitude of the profession. He came from a middle class family and recognized in this occupation a way of economic advancement in a job he enjoyed. Why then does he bear a grudge against his college training?

This student objects to the coldness of his education, to the completely impersonal way technical knowledge was shoved down his throat, to the fact that his formal training for living consisted of classroom facts and figures, and nothing more. In this day of specialization the responsibility for his mental and social development has been delegated haphazardly to his rooming house, the corner drug store, the local bar and night club, his family 500 miles away, his church, his fraternity, his club, and the dean of men who instead of worrying about fifty men worries about five hundred. His education has been entrusted in a host of people each of whom says his job is to deal with just one aspect of the student's total training, and this one aspect alone, disclaiming responsibility for all others. Is it wrong, then, to question the wisdom of over-specialization in education as opposed to a more personalized mentor-system; and to speak of teacher responsibility and influence outside the classroom?

Impenetrable Gulf Between Teacher and Student

Under the system presently developed the student in his Freshman and Sopho-

* Presented at the Chemical Engineering Summer School, sponsored by the Chemical Engineering Division, A.S.E.E., University of Wisconsin, August, 1948.

more years is lucky if he gets within twenty rows of the man with the chalk, who rightly or wrongly is a sort of hero to him. In the last years he becomes well enough known to have a general label of good, bad, or indifferent and a full name to the man who is putting the ideas across the desk; but the teacher-pupil relationship effectively goes no further than a first introduction at a formal party. At no point in his college life has the student met what he instinctively felt was true educational inspiration from a great teacher, all of whom seem to be hidden away somewhere for graduate students and special occasions, or who are so remote that it would have been better to pore over the impersonal text books of the great man and have never entered the campus gate.

If the student has an adviser, he may see him individually, and perhaps alone man to man, fifteen minutes each semester. If he ever had the honor of personally meeting the dean of his college or the president of the university, his crime must have been particularly heinous, and his remaining student days less than none at all.

When the student steps out of the classroom, that moment is the last he will see his professor until the class meets again. If he joins a professional group, he does not find him at the regular meetings. He does find someone else who is low in seniority and is there not because he wants to be there and enjoys directing student activities but because he is required to be there as part of his job. Rarely in his extracurricular activities does the student find the guiding presence of his classroom teachers whose avowed purpose is to prepare him for professional life and who could represent some sort of unifying factor in his education. His idea on how much time his teacher should spend on his training is unfair and unrealistic, but the student unconsciously wants something more from education than the mental tools to attack physical problems.

Instilling Professional Attitudes

Technical training has created groups of professional people who are scurrying around changing our everyday world. Engineering attracts the best talents of the best people because its purpose is well defined, and it moves with certainty obtaining indisputable results. In this profession there is no necessity for lapsing into platitudes on known subjects, and it is dangerous to cover one's tracks with involved verbiage and vague guesses on unknown subjects. But, in an attempt to be completely objective and professional, the engineer, as well as the scientist, has been unaware of the consequence of his achievements, and now awakes to the realization that his work is being misused, that technology is a social and political force and should be treated as such a force. Knowledge in itself is not enough. And by analogy classroom education is not enough.

Recently every engineering curriculum has been altered to include more of the so-called "humanities," but is this the sufficient answer to a need for something more than professional knowledge? Perhaps some extracurricular education by engineering teachers could contribute to a solution, and inject true purpose into the lives of students.

If you are a teacher, what can you say to these questions about each of your many pupils?

What is his background?

Where does he live and what sort of a life does he lead outside the classroom?

Is his social and economic level being improved?

What latent talents worth developing does he possess?

What shortcomings, susceptible to correction, hamper him?

What sort of person is he?

Is he developing into a better man?

Is he being educated with something besides technical knowledge?

The student recognizes a good teacher with unfailing instinct. He is not nec-

essarily the oldest member of the faculty, nor the most brilliant, nor the one with the largest number of scientific papers to his credit, nor the one who gives the best marks, nor the best business administrator, nor the best politician. He is the good classroom lecturer; he takes his work seriously and puts much time in on it; he inspires his pupils with a desire to learn; he is not a cruel taskmaster but demands and gets the very best efforts of his students; he is completely interested in the education of each individual and in his mental and social development; his friendship is respected; his advice and counsel is accurate and effective; he does not pretend but is accepted for what he knows and what he is.

A pupil wants his teacher to be "human," but present practice conspires to make college professors as inhuman and impersonal as possible, little better than the lifeless pages of a textbook. College students cannot expect the exclusive attention of a tutor, but they should be able to hope for some of the personal and human inspiration that a closer teacher-pupil relationship can provide.

When the student walks away from the classroom at the end of a lecture hour or laboratory period, he does not walk away from the process of education. If he is a youth of any talent or any depth he keeps on absorbing experience and knowledge like a sponge. The average university lists for the student 25 hours per week of direct supervision by teachers who are charged with his training. These 25 hours represent only 15 per cent of his student life and, we dare say, about the same percentage of his education for leading a worth-while and useful existence.

Whether or not the teacher should feel responsibility for the education of students outside the classroom is not for us to ask; but we can wonder whether or not the teacher's interest in, and influence on, all phases of the students' education outside, as well as inside, the classroom is not directly propertional to his qualifications and success as a teacher.

ECPD Annual Meeting

The following is a summary of the reports presented by the various committees of the ECPD at its annual meeting, held at the Edgewater Beach Hotel in Chicago, October 28–29, 1949.

Accreditation of Engineering Colleges

A vigorous program of reaccreditation of engineering curricula in engineering colleges has been undertaken by the Engineers' Council for Professional Development, an organization representing the major engineering societies of the country. The first program of accreditation was completed in 1943. Because of wartime restrictions, accreditation was discontinued until 1947. The Committee on Engineering Schools of the ECPD, under the Chairmanship of H. T. Heald, President of the Illinois Institute of Technology, has completed inspection of 114 colleges. Only 39 schools remain to be inspected in the immediate postwar program, and it is anticipated that these inspections will be completed during the coming year. Approximately 74% of all the engineering curricula inspected have been fully accredited; 14% have been provisionally accredited; and 11% have not been accredited.

The Committee on Engineering Schools is also studying the problem of the accreditation of graduate curricula in engineering colleges. This is a difficult problem since there is a widespread diversity in beliefs among educators as to what constitutes the objectives of graduate study. One of the principal undertakings of the Committee on Engineering Schools has been the preparation of a definitive statement as to the characteristics of a good engineering curricula. This will be useful as a guide to administrators of engineering colleges as well as in the work of the accrediting committees. The Committee on Engineering Schools has carefully refrained from specifying course content in engineering curricula, since it believes that engineering colleges should have full freedom in method, procedures, and extent of training. However, the Committee feels that there are certain minimum requirements which an engineering curriculum should satisfy.

The Committee on Engineering Schools has also accredited curricula in thirteen technical institutes.

Professional Training

The Committee on Professional Training of the Engineers' Council for Professional Development, under the Chairmanship of A. C. Monteith, Vice President of Westinghouse Electric Corporation, is making a survey of industrial training programs and educational courses available to the practicing engineer in industry. There is an ever increasing need for continued professional education after the engineer embarks upon his career, and the Committee on Professional Training is endeavoring to encourage such educational programs in order to provide a greater depth and breadth of education for engineers.

The Committee on Professional Training is also preparing material on: (1) professional registration of the young engineer, (2) the engineer's place in the community, and (3) a personal appraisal for engineers.

Student Selection and Guidance

A Committee on Student Selection and Guidance of the Engineers' Council for Professional Development, under the Chairmanship of Z. G. Deutsch, consulting engineer, New York City, is studying the problem of improving the vocational guidance of high school upper classmen. A survey has been conducted which shows that very little effort has been made by professional organizations to assist the high schools in this very important human problem. Plans are being formulated to stimulate a more widespread type of guidance work which would be carried on by public-spirited professional engineers throughout the United States. This Committee is also preparing a new pamphlet which will provide an insight into the profession of engineering and will serve to supply vocational guidance information. The pamphlet will be available to principals, librarians, guidance counselors, and students in high schools and colleges.

THE T-SQUARE PAGE

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Devoted to the Interests of Engineering Drawing

W. J. Luzadder, *Editor*
Purdue University

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Professor Frank H. Heacock, Chairman
Engineering Drafting Committee of
The American Society for Engineering Education
Princeton University
Princeton, New Jersey

Dear Professor Heacock:

With the ever-increasing amount of technical knowledge that is developing in the modern world, it is inevitable that engineering colleges are continually studying their curricula to see how additional technical work can be included. In some cases, it appears that the fundamentals of engineering, on which sound engineering education is based, are threatened. It has been reported that several engineering colleges have reduced the amount of drawing to a dangerous minimum.

Representatives of industry often stress the importance of the basic subjects—mathematics, physics, chemistry, English, engineering drawing, mechanics—in the curriculum. After serious consideration of this attitude on the part of industry, and the trend of the colleges to reduce the basic training, particularly in engineering drawing, the following resolution was adopted unanimously by the Board of Directors of The Engineering Society of Detroit at their last meeting:

> Resolved, that The Engineering Society of Detroit advise the Engineering Council for Professional Development and the drawing division of The American Society for Engineering Education of its vigorous support of the retention of adequate training in Engineering Drawing in all engineering curricula.

We respectfully urge that The American Society for Engineering Education lend its support to our efforts to combat the trend of the colleges to reduce the basic training in engineering drawing, and thank you in advance for anything you can do toward the attainment of this worthy objective.

Very truly yours,

Frank G. Horton,
Managing Director

New Members

ALBROOK, R. L., Director, Division of Industrial Research, Washington State College, Pullman, Wash. E. B. Parker, H. A. Sorensen.

AMBROSE, HARRY H., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, A. T. Granger.

BARTKUS, EDWARD P., Assistant Professor of Chemical Engineering, West Virginia University, Morgantown, W. Va. P. R. Jones, H. V. Fairbanks.

BREAULT, E. EDWARD, Assistant Technical Personnel Director, Ingersoll-Rand Company, New York, N. Y. J. C. McKeon, G. D. Lobingier.

BRENNAN, CHARLES W., Assistant to the Dean, College of Engineering, University of Alabama, University, Ala. F. R. Steinbacher, W. D. Jordan.

BRIGHT, B. BROOKS, Personnel Supervisor, Industrial Relations, The Atlantic Refining Company, Philadelphia, Pa. W. F. Houghton, J. M. McIlvain.

BROWN, JAMES H., Assistant Professor of Engineering, University of Omaha, Omaha, Neb. J. W. Kurtz, C. H. Prewett.

BROWN, ROBERT R., Professor and Head, Electrical Engineering Dept., University of Massachusetts, Amherst, Mass. C. E. Tucker, T. S. Gray.

CHILDS, WYLIE J., Associate Professor of Metallurgy, Lafayette College, Easton, Pa. W. P. Plant, F. W. Slantz.

CROOK, CHARLES W., Instructor in Engineering Mechanics, University of Arkansas, Fayetteville, Ark. W. C. Clark, W. B. Stiles.

CUTTS, CHARLES EUGENE, Instructor in Civil Engineering, University of Minnesota, Minneapolis, Minn. G. J. Schroepfer, M. S. Kersten.

DALLAVALLE, JOSEPH M., Professor of Chemical Engineering, Georgia Institute of Technology, Atlanta, Ga. R. L. Sweigert, J. W. Wilson.

DASKIN, WALTER, Instructor in Mechanical Engineering, The Johns Hopkins University, Baltimore, Md. D. H. Fax, A. G. Christie.

DAVIS, HAROLD S., Assistant Professor of Civil Engineering, State College of Washington, Pullman, Wash. E. G. Ericson, R. D. Harbour.

ELLIS, GREER, Consulting Engineer, Ellis Associates, Pelham, New York. A. H. Church, S. A. Gertz.

ENGELMANN, RICHARD H., Instructor in Electrical Engineering, University of Cincinnati, Cincinnati, O. W. E. Restemeyer, A. B. Bereskin.

ERICKSON, FREDERICK K., Assistant Professor of Civil Engineering, State College of Washington, Pullman, Wash. E. G. Ericson, B. Fried.

FLEMING, JULIAN R., Associate Professor of Hydraulic and Sanitary Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, A. T. Granger.

FRANZINI, JOSEPH B., Assistant Professor of Civil Engineering, Stanford University, Stanford, Calif. B. M. Green, E. Grant.

FREDRICKSON, ROBERT E., Instructor in Chemical Engineering, University of North Dakota, Grand Forks, N. D. M. H. Chetrick, J. J. Daly.

FRIEDERICH, ALLAN G., Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill. L. D. Walker, S. G. Hall.

GAMMELL, JOHN, Supervisor of Sales Training, Allis-Chalmers Mfg. Co., West Allis, Wis. F. T. Agthe, J. L. Singleton.

HOLDER, WILLIS G., Assistant Professor of Industrial Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, H. W. Risteen.

JOHNSON, RICHARD P., Associate Professor of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pa. J. W. Graham, Jr., J. B. Rosenbach.

JONES, CHARLES S., President, Academy of Aeronautics, LaGuardia Airport Station, New York, N. Y. W. M. Hartung, Thorndike Saville.

JONES, WILBUR DALE, Assistant Professor of Industrial Engineering, Georgia Institute of Technology, Atlanta, Ga. F. F. Groseclose, D. B. Wilcox.

KAMMERMEYER, KARL, Professor and Head, Division of Chemical Engineering, State University of Iowa, Iowa City, Iowa. A. H. Cooper, F. M. Dawson.

KELLER, DUANE R., Assistant Professor of Civil Engineering, University of Maryland, College Park, Md. J. B. Cournyn, P. A. Wedding.

KING, CHARLES D., Assistant Professor of Mechanical Engineering, University of Idaho, Moscow, Idaho. N. F. Hindle, J. H. Johnson.

KNUDSEN, VERN O., Dean of the Graduate Division, University of California, Los Angeles, Calif. C. J. Freund, A. B. Bronwell.

LETT, ROBERT P., Assistant Professor of Electrical Engineering, Syracuse University, Syracuse, N. Y. R. D. Whitney, R. A. Galbraith.

LEWALD, CHARLES E., Assistant Professor of Civil Engineering, Washington University, St. Louis, Mo. L. E. Stout, F. W. Bubb.

MASLAN, FRANK, Assistant Professor of Chemical Engineering, New York University, New York, N. Y. R. E. Treybal, J. Happel.

MAY, DONALD C., Mathematician, U. S. Civil Service, Bureau of Ordnance, Navy Dept., Washington, D. C. R. S. Burington, A. B. Bronwell.

MEDLEY, GEORGE A., Instructor in Mechanical Engineering, Washington State College, Pullman, Wash. C. C. Johnson, R. D. Harbour.

MELLOW, ERNEST W., Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. H. O. Croft, R. H. Luebbers.

MONDSCHEIN, JULIUS, Instructor in Civil Engineering, Union College, Schenectady, N. Y. M. F. Sayre, C. E. Williams.

MUELLER, JAMES I., Assistant Professor of Ceramic Engineering, University of Washington, Seattle, Wash. C. L. Wilson, R. Z. Williams.

OJALVO, MORRIS S., Instructor in Mechanical Engineering, University of Delaware, Newark, Dela. J. I. Clower, W. E. Piper.

OLDHAM, FRANK D., Professor of Chemical Engineering, University of Missouri, Columbia, Mo. H. O. Croft, R. H. Luebbers.

OWNBEY, CHARLES R., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, J. H. Williamson.

POTTER, RICHARD C., Associate Professor of Mechanical Engineering, Kansas State College, Manhattan, Kan. M. A. Durland, C. H. Scholer.

QUICK, ROY T., Associate Professor, Engineering Extension, Iowa State College, Ames, Iowa. F. Kerekes, J. K. Walkup.

RAYMOND, JACK D., Coordinator of Cooperative Work, Northeastern University, Boston, Mass. J. W. Zeller, W. E. Nightingale.

REED, G. NATHAN, Dean of Faculty, Lowell Textile Institute, Lowell, Mass. M. Hindle, M. E. Gelinas.

REGLEIN, NED L., Visual Aids Director, John Wiley & Sons, Inc., New York, N. Y. W. B. Wiley, J. S. Snyder.

RICE, PAUL P., Associate Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. A. R. Johnson, M. T. Ayers.

ROBERTS, WILLIAM H., JR., Assistant Professor of Mechanical Engineering, New York University, New York, N. Y. I. T. Wetzel, A. B. Bronwell.

ROBINSON, ROBERT E., JR., Executive Assistant to the Dean, College of Engineering, New York University, New York, N. Y. Thorndike Saville, M. O. Giannini.

SCHMIEDER, ALBERT K., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferrerri, F. A. Stearns.

SCHREIBER, HERBERT F., Coordinator, Examinations and Grading, U.S.A.F. Radio School, Belleville, Illinois. W. C. Krathwohl, H. T. Heald.

SHARPE, NORMAN, Head, Refrigeration and Air Conditioning Dept., California State Polytechnic College, San Luis Obispo, Calif. C. E. Knott, F. H. Gertz.

SMITH, HENRY B., Professor of Chemical Engineering, Bucknell University, Lewisburg, Pa. A. M. Cooper, G. A. Irland.

STEELE, THEODORE K., Instructor in Mechanical Engineering, New York University, New York, N. Y. W. E. Schorr, E. A. Salma.

TAYLOR, BRITTON M., Training Supervisor, Engineering Dept., E. I. duPont de Nemours & Co., Wilmington, Del. M. J. Bergen, C. S. Robinson.

TOMKINS, STANTON E., Instructor in Mechanical Engineering, University of Michigan, Ann Arbor, Michigan. F. L. Schwartz, J. M. Nichelsen.

TRUMBULL, ROBERT G., Associate Professor of Mechanical Engineering, The George Washington University, Washington, D. C. C. H. Walther, C. E. Greeley.

URBACH, WALTER F., Assistant Professor of English and History, Massachusetts Institute of Technology, Cambridge, Mass. H. R. Bartlett, J. N. Ulman, Jr.

WANG, CHU-KIA, Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. G. Dobbins, W. Raeder.

WHITE, ARDIS H., Assistant Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, R. C. Wray.

WHITFIELD, JOHN K., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. J. S. Doolittle, R. W. Truitt.

WISEMAN, JAMES H., JR., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, R. C. Wray.

WRIGHT, EDWIN C., Head, Metallurgical Engineering Dept., University of Alabama, University, Ala. F. R. Steinbacher, W. G. Keith.

YAMPOLSKY, JACK, Instructor in Mechanical Engineering, The Cooper Union, New York, N. Y. W. S. Kut, W. Vopat.

HERTZ, DAVID B., Assistant Professor of Industrial Engineering, Columbia University, New York, N. Y. D. B. Miller, W. S. Hennessy.

SHERLIN, GROVER C., JR., Hydraulic Engineer, National Bureau of Standards, Hyattsville, Md. C. E. Bardsley, J. Hilsenrath.

66 Applicants this list.
149 Previously elected.

215 New members elected this year.

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

Seattle, Wash. June 19–23, 1950

The Yardstick of Quality

By F. M. DAWSON

Vice President of the ASEE and Chairman of the Engineering College Research Council

Dean of Engineering, University of Iowa

After many long and often fruitless discussions about the importance of differentiating *basic* from *applied* research, it is refreshing to read the remarks of President J. L. Morrill in opening the Symposium on Engineering Research at the University of Minnesota in March, 1949. "I have very little interest in the ancient argument over basic and fundamental versus applied research," said President Morrill.[1] It poses, he continued, an unrealistic problem—and he noted Arthur Morgan's "rather brusque remark that when a scientist expresses unconcern for the usefulness of research, he means simply that he does not accept current appraisals of its value."

There are, then, criteria other than "fundamental" which may far more effectively be used to select research problems most suitable for study in colleges and universities.

One such criterion would seem to be the *newness* of the research problem and the unpredictability of its direction and probable results. There is no great educational or scientific benefit in merely repeating an experiment already described by others; nor is there real educational benefit to be derived from routinely testing 999 vacuum tubes statistically taken from a factory's output. The value of research to an advanced student is primarily his lesson in how to go about learning things which have never been learned before. It is well for us all that, by the very nature of this educational process, students and their guiding teachers contribute new knowledge valuable to the nation and its industries.

To some extent, size may also be a helpful criterion in selecting research projects for the attention of educational institutions. When any research program becomes large and complex, it may become the tail that wags the dog. As Dean T. K. Sherwood pointed out before the Engineering Division of the Association of Land-Grant Colleges and Universities in October, 1949,[2] under such conditions there is a real possibility that educational goals will be subordinated to research goals. Colleges and universities are *educational* institutions.

Some research projects, too, can be judged by the people who are at work on them. When a project requires the attention of full-time research people, over a long period, there is the likelihood that both faculty and students are being deprived of valuable part-time research experience. This is not to say that faculty and students should do routine and mechanical work on any project; there are ample grounds for making full-time technicians available. The goals of a university are not served by assembling numbers of scientists and engineers who take no active part in the institution's educational program and academic life.

At the Engineering College Research Council's Annual Dinner at the Rensselaer Polytechnic Institute, Dean A. F. Spilhaus described the essential difference between industrial research and university research in terms of the yardsticks applied.[3] Industrial and commercial organizations must measure their research in terms of both quality and potential profit, he said. Universities are

in the fortunate position of needing only the single yardstick of quality.

This would seem an excellent standard by which educational institutions and their faculties may gauge their performance of scientific research in the light of their very real opportunities and obligations. The aim should be to have really good research projects at each College of Engineering rather than have the work concentrated at a few institutions.

REFERENCES

1. Address of Welcome to the Symposium on Engineering Research, *Proceedings* of the Symposium, Bulletin No. 29 of the University of Minnesota Engineering Experiment Station, August, 1949, p. 3.
2. "The Relation of Research to Engineering Education," by T. K. Sherwood, Dean of Engineering, Massachusetts Institute of Technology; presented at the Engineering Division, Association of Land-Grant Colleges and Universities, Kansas City, Missouri, October 25, 1949.
3. "Important Intangibles in Cooperative Research," by A. F. Spilhaus, Dean of the Institute of Technology, University of Minnesota; scheduled for early publication in the *Proceedings* of the 1949 Annual Meeting, Engineering College Research Council.

College Notes

Ayer Hall, a new $500,000 College of Engineering building at the **University of Akron** was dedicated October 21, 1949, by holding open house, unveiling a portrait of Dean Emeritus Frederic E. Ayer and a dinner meeting at which A. A. Potter, Dean of Engineering at Purdue University, addressed educators, industrialists and alumni. A total of 40,000 square feet of floor space is provided on four floors and the building houses the departments of Civil, Electrical and Mechanical Engineering, with the exception of several laboratories, and the Mathematics Department. While the University is a municipal tax supported institution, the building was financed by donations from Akron industries and alumni. It is the second building to be completed under the present expansion program.

The new head of the Department of Mechanical Engineering at **Michigan State College** is Leonard C. Price, a member of the MSC staff since 1942. Prof. Price, who received B.S. and M.S. degrees from Cornell University, served as instructor at Cornell 1922–26; research associate at the University of Arkansas 1926–38; and as associate professor at the University of Arkansas from 1938 to 1942.

Frederick D. Rossini, Chief of the Thermochemistry and Hydrocarbons Section of the National Bureau of Standards, has been appointed Professor and Head of the Chemistry Department at **Carnegie Institute of Technology**, President Robert E. Doherty announced.

Vacation Possibilities of the Northwest

58th Annual Meeting
University of Washington
Seattle, Washington, June 19–23, 1950

By RALPH GANO COWLES

Humanistic Social Studies Department, College of Engineering, University of Washington, Seattle 5, Washington

The A.S.E.E. convention, scheduled to open June 19, 1950, at the University of Washington, offers a splendid opportunity for an extended vacation in the State of Washington, in Canada, and in Alaska. The Pacific Northwest is an "Evergreen Playground" where the vacationer will get his "money's worth and see everything there is to see." Less than ninety miles north of Seattle, Canada offers infinite vacation possibilities. An air trip to the heart of the Alaska country is both fast and inexpensive.

By the use of alternate routes on the trip to and from Seattle, the vacation traveler may visit many of the West's most scenic spots. The northern trip will take the traveler through the Dakota Badlands to Wyoming and Jackson Hole. From there he will visit the Rocky Mountains and Yellowstone Park. From Yellowstone the trip winds through Montana and the hills of Idaho to the eastern border of Washington. The southern route is traced through Colorado and Utah, through the southern limits of Idaho and the eastern boundaries of Oregon, with a long and beautiful drive down the Columbia River to Portland.

Before setting out on a trip to the Northwest the tourist would be well advised to visit his favorite service station for information concerning the travel guide services provided by the various oil companies. The larger companies furnish, free of charge, complete map service indicating the best places to make stopovers and the most outstanding sights along the various routes.

Grand Coulee Dam

Eastern Washington is world-famous for the giant dam at Grand Coulee. Completed in 1942, this dam is located at the head of Grand Coulee, a chasm 52 miles long and 1½ to 5 miles wide, in a geological wonderland only 92 miles from Spokane, the capital of Washington's "Inland Empire." Damming the mighty Columbia, the second largest river in America, the project supplies much needed power and water for the vast Columbia Basin Irrigation Project. During the war the dam's power output rose to a maximum of 962,000 kw. By 1948 the West Powerhouse with its full installation of nine generators could develop a peaking capacity of 1,125,000 kw. of electric energy. Primary, or firm, power may reach 9,000,000,000 kwhr. annually. This grand engineering achievement is indeed a "must" on the vacation traveler's itinerary.

The air-minded traveler will miss much of the pleasure to be gained by motoring through the country; but he will have ample opportunity to make up for it in side trips out of Seattle, the heart of the Northwest's Cascade and Olympic Mountain playground, into the numerous lakes and vast reaches of salt water that fill the Puget Sound Basin. Travel by air

to Seattle is swift and easy from almost any point in the Americas. The airlines flying into the Seattle-Tacoma airport at Bow Lake provide special vacation rates for family groups which compete successfully in cost with other types of transportation. Daily flights out of Seattle bound for Alaska and the Orient are included on the special vacation rates.

North of Washington lies the westernmost province of Canada, British Columbia, with its beautiful city of Victoria reflecting the spirit and glory of old England in the "bobby" on the corner and in the formal gardens surrounding the many beautiful buildings. Both Vancouver and Victoria offer the tourist British and Canadian manufactured goods at reasonable prices. The devaluation of the British pound sterling may result in many worthwhile bargains in English bone china and Scottish Tweeds.

The traveler intending to visit Canada should bring in his billfold documents such as his birth certificate or voter's registration card, as proof of his U. S. citizenship. If he plans to take his car, an insurance-liability card will make it easy for him if he forgets where he parked it and has it picked up by the Canadian Mounties.

Trips to the North Country

Those who plan to spend some time in the Canadian wilds may wish to make an extended trip to Lake Louise and the internationally famous resort at Banff, some three hundred miles north and east of Spokane. The best highway is out of Spokane through Bonners Ferry, Idaho.

Daily flights from Seattle to Alaska can be made for as little as seventy dollars, plus tax, to points on the Alaska coast. A flight to Anchorage will bring

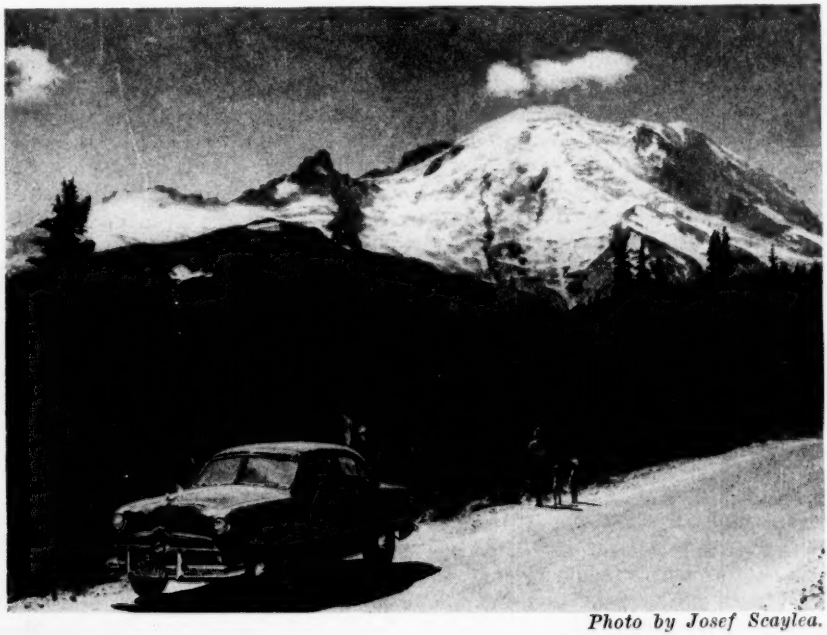

Photo by Josef Scaylea.

Skies may be sunny and the evergreens throwing shadows across the highway but Mount Rainier presents a snow-capped picture the year around. Here's how Rainier looks from Chinook Pass on a sunny afternoon.

the traveler close to some of Alaska's trackless wilderness. Travel in Alaska is largely by air.

Those who wish to sail to Alaska via the Inside Passage should write to the Seattle Chamber of Commerce for information concerning the charter boats which make the trip each year. Reservations must be made very early, since the boats are limited in size. The Inside Passage to Alaska is used each year by many small-boat operators who fish in Alaskan waters.

Shorter trips out of Seattle to Mt. Rainier and Mt. Baker, for mountain climbing and hiking, are easily arranged. Mt. Rainier National Park is only 90 miles from the Seattle city limits. Snow-crowned, the mountain, towering 14,408 feet, is the second highest in the United States.

The traveler may make an extended trip around the Olympic Peninsula and through the Olympic National Park, one of the wildest regions left in America. Near the extreme northern end of the Peninsula lies Lake Crescent at the foot of Mt. Olympus. The wilderness of this section of the peninsula is penetrated only by hiking trails. Lake and stream fishing is perfect, in this naturally beautiful setting.

Fishing trips in Puget Sound may take the vacationer up the Sound from Seattle to the many San Juan islands which are dotted with resorts and cabins available to the summer visitor. Many of the islands have excellent beaches, though the Sound water is too cold for a very prolonged swim. Boys' camps and summer camps for girls are located on some of the islands of the San Juan group, providing outdoor life in rugged terrain with the natural beauty of the Northwest at its best.

Seattle Offers Variety

But the convention vacationer need hardly go beyond the city limits of Seattle to enjoy a thrilling and highly educational summer. Once called the last jumping-off place of civilization, Seattle still retains much of the glamour and many of the landmarks of the old days of the Alaska Gold Rush. Despite the conquest of the giant timber growth, many Douglas fir and Red Cedar still cloak the slopes of the Cascades and Olympics which guard Puget Sound. Situated on the western shores of Elliott Bay, an arm of Puget Sound, Seattle is almost surrounded by water. On its east side lies Lake Washington, a fresh-water lake almost twenty-five miles long and four miles wide at several points. Green Lake, Lake Union—in the heart of down-town Seattle—and Lake Washington provide many Seattle residents in their hilltop homes a view of one of the lakes.

Lake Union provides moorage for hundreds of houseboat homes along its shores. Out in the deeper waters of the lake are moored many deep-sea boats; these have been towed into the lake by powerful tugs from Elliott Bay through the ship canal constructed between the bay and the lake with a system of locks second in size only to those in the Panama Canal. The ship canal also extends into Lake Washington, making available many miles of moorage and docking space which gives Seattle the distinction of having more small boats and pleasure craft per capita than any other city in the world.

Boat races and regattas are held each week during the summer. Hundreds of spectators crowd Lake Washington's unique floating bridge to view the boat races. The city has three yacht clubs, and the competition between the various boat owners is keen. Many boats are available for charter by the day or week. The vacationer may also take scenic rides on ferry boats to interesting points on the Sound. A typical one-day tour of Seattle's waterways starts at the dock in downtown Seattle and threads through the Sound to the lake and back.

Seattle, of course, is famous all over America for its fine seafood. Many fine restaurants specialize in Dungeness crab,

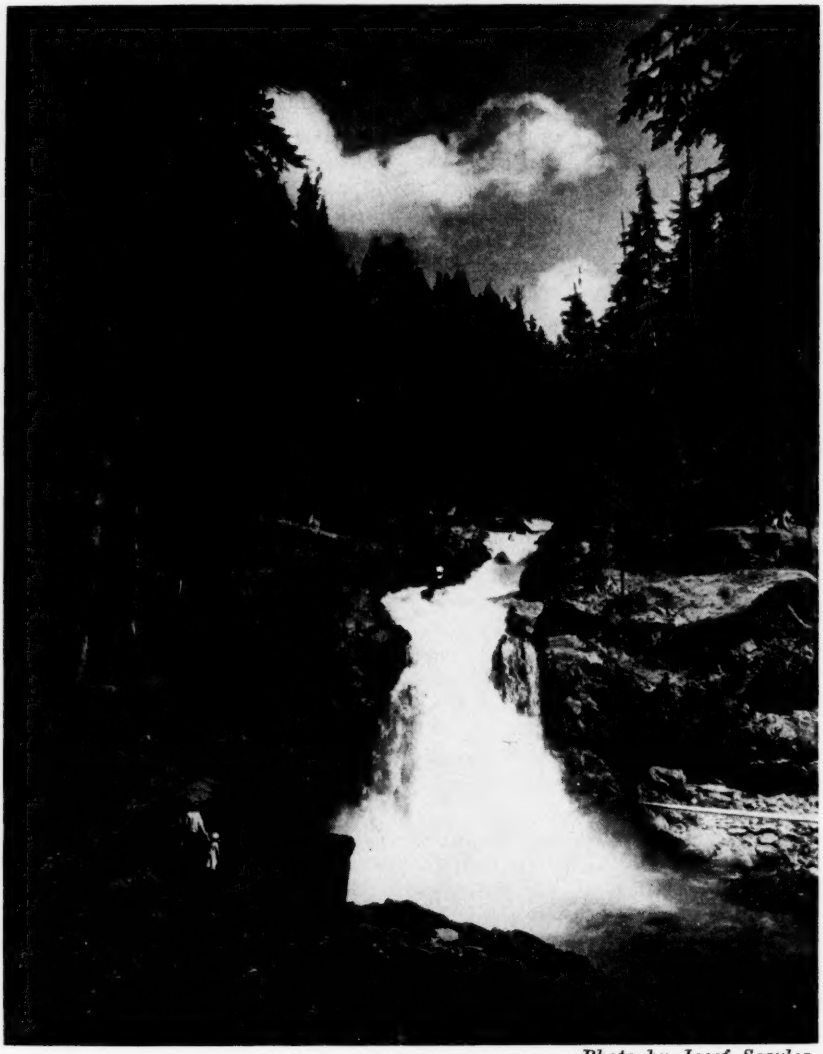

Photo by Josef Scaylea.

A breathtaking sight is this view of Silver Creek Falls in Rainier National Park. Ribbon-like, the mountain stream winds its way through trees and underbrush to crash to the rocks below.

Olympic oysters, and fresh salmon, served variously in all the fine eating places in the Northwest.

Seattle's Chinatown is perhaps not as well known as that of San Francisco, but the Chinese restaurants provide the finest in Chinese-American food.

The Seattle Art Museum, at Volunteer Park, has one of the few outstanding collections of Chinese and Japanese art in the world. This collection is displayed each summer as an attraction for the thousands of tourists who visit the Northwest.

Many dark things have been said about Seattle weather, but on the average the "sunny days" compare favorably with the best weather of other states, and although rain does fall, most Seattleites would deny that "it is always wet." On the whole, summers are cool, with few cloudy days during the months of June, July, and August. The traveler planning to spend the summer months in the Northwest should bring clothing appropriate for cool nights and warm days. A light topcoat for evenings often seems desirable to persons coming from warmer climates.

No bears now roam the campus, no Indians hunt scalps, but the Pacific Northwest still offers its guests the traditional western hospitality.

Those who plan to spend a few weeks vacationing in the West after the close of the annual meeting would do well to write (a) the Seattle Chamber of Commerce for further recreational possibilities and information on housing, (b) the Alaska Steamship Company, Seattle office, for reservations, which must be made well ahead of time, and (c) the Alaska-States Air Travel, Inc.

The Canadian Pacific Railway has a ten-day cruise leaving Vancouver on Saturday evening, June 25, and returning to Vancouver on Tuesday morning, July 5. The Cruise is up the Inside Passage to Skagway and stops are made at intermediate points. The minimum cost of this cruise is $184 including tax and meals. Reservations should be made before the end of January. They may be obtained by writing directly to Mr. C. C. Jordan, Canadian Pacific Railway, 1320 4th Avenue, Seattle, Washington. The railroad trip from Seattle to Vancouver takes about 4½ hours.

The Alaska Steamship Company offers twelve day cruises to Seward, Alaska. The minimum cost is approximately $228 for a lower deck room, including tax and all meals. Requests for reservations should be addressed to Mr. K. A. Cross, Assistant General Passenger Agent, Alaska Steamship Company, 823 2nd Avenue, Seattle 4, Washington.

College Notes

Succeeding Dean and Director M. L. Enger, who after forty-two years of service to the **University of Illinois** reached retirement age this summer, Professor William L. Everitt became head of the College of Engineering and the Engineering Experiment Station on September 1. He was succeeded as head of the department of electrical engineering by Dr. John D. Ryder, professor and assistant director of the Engineering Experiment Station of the Iowa State College. Other new appointees include Professors Frederick Seitz and James H. Potter, 4 associate and research associate professors, 8 assistant and research assistant professors, 15 instructors, and 2 special research associates, besides 46 research assistants and 50 non-research assistants.

Maintaining Our Industrial Leadership Through Engineering[1]

By M. E. COYLE

Executive Vice President, General Motors Corporation

Dr. L. W. Houston, President of Rensselaer Polytechnic Institute, has spoken of the need for better understanding and closer relationship between industry and the colleges, particularly those engaged in engineering education. The degree of financial responsibility of industry to educational institutions has never been clarified. But there are many concerns at the present time making specific grants to schools in connection with research work which applies to their particular activity. This list is rapidly increasing, both in number of participants and amount of funds assigned.

Industry, as well as the colleges, has certain objectives and a share of the problems. We who have served many years in industry and have participated in its expansions should be able to draw upon our experience and offer counsel as to how the objectives may be achieved and some of the problems solved.

The industrial leadership that we have attained and which we are desirous of maintaining and expanding, was not accomplished by engineering alone. We know that engineering has made a major contribution and that without it we could not have reached our present position. However, engineering needed the support of an efficient production department, as well as a capable distribution organization to make the products available to the customers on an even-flow basis. Most important of all was the role of the money invested in the enterprise by the stockholders under what we call the free enterprise system and the American way of life.

As a matter of fact, we have possibly abused the free enterprise system and American way of life terminology to some extent. It simply means the right of every individual to make a financial investment of his own choice—the right to lose his shirt if he invests unwisely—the right, and always the hope, of an increase in the value of his capital and some return in the form of dividends if he is more fortunate.

I have seen many stimulating influences and also recognize many that are retarding the development of industry. If the present trend is continued, I am afraid there is trouble ahead of us. To cover these points adequately I must speak on a broader basis than the title of my talk as given by your Chairman would indicate. We are interested in more than the maintenance of industrial leadership. Dean Freund wrote me under date of March 9th and said, "May I suggest you discuss any subject you choose which has to do with the positions and problems of the American industries and the automobile industry in particular." I am going to take advantage of his suggestion for the following reason.

Industry's Viewpoint

Last December a number of industrial concerns, including United States Steel,

[1] Presented before a General Session of the 57th Annual Meeting of the ASEE, Troy, N. Y., June 21, 1949.

General Electric, General Motors and several others, were requested to appear before a Congressional Committee in Washington and supply information in respect to prices and profits. The attitude of the committee in regard to the size of the corporations and the amount of their profit came as a distinct surprise. During our appearance for General Motors the Committee highlighted the position of leadership attained by General Motors during the forty-one years of its existence, following its organization in 1908. They stated that General Motors had reached its present position honestly and in an open competitive market; that it had not done so by having control over limited natural resources.

They stated, however, that General Motors was too big and must, therefore, be put under some sort of control. They concluded their comments by stating that it was a problem with which the Congress would have to deal in a manner that was not at the moment entirely clear.

Subsequently, the May issue of *The Nation's Business* carried an article by Senator Flanders, Chairman of the Committee in Washington, in which he referred specifically to part of the testimony given by General Motors. In the April issue of *Reader's Digest* was an article by Senator O'Mahoney, another member of the Committee, referring to the bigness of industry. On the floor of the Congress, Representative Helen Gahagan Douglas of California made the following statement: "One year's earnings after taxes of one corporation, General Motors, doubled the assets of the 32 major labor unions in the whole country . . . which must provide protection for 8 million people . . . less than 28 pitiful dollars per person."

All of these comments follow a similar pattern and while we feel that Congress will not legislate against General Motors specifically—whatever laws are passed will apply to all corporations—they do indicate a retarding influence in respect to the development and expansion of industry. It is this trend that indicates there is trouble ahead of us unless the trend is reversed. Government should encourage, not discourage, industry.

During the Washington hearing the statement was made on several occasions that profits of all United States corporations in 1948 exceeded 20 billion dollars. Some of the witnesses questioned the accuracy of these figures. Reference was made to the influence of inflation, the lessened purchasing power of the dollars which would reduce the value of these so-called profits. Others directed attention to the allowable depreciation rates being inadequate to permit replacement of capital facilities at current costs. I do not feel the accuracy of the figures is at all important. What I believe to be important is the fact that the reported profits of all United States Corporations for 1948 are less than half the Federal budget now before Congress and which the present administration proposes to spend during the next fiscal year. It is extremely important to realize that our country cannot afford to spend 42 billion dollars in any peacetime year.

Large Corporations Are Indispensable

As to the size of corporations, our recent experience in World War II should indicate that the greatest productive asset of our country was the large corporations. They could accomplish so many things that never could have been done by smaller business concerns. I am convinced that the Allies could never have won the war without the production facilities and products of the United States Steel Corporation. I do not believe the war could have been won without the production of General Motors and certainly it could not have been accomplished without the support of the automotive industry.

General Motors alone made over 206,000 of the airplane combat engines that were used in World War II. It sold to the Allies more than 12 billion dollars worth of war materiel at a mark-up of less than half of the peace time rate over cost. The United States sent on Lend-

Lease 11 billion dollars worth of materiel to Russia. If the Russians had had one General Motors they would not have needed Lend-Lease.

A great part of our industrial progress has occurred in the past fifty years. We have capitalized the inventions of the preceding century. Our population has doubled in those fifty years and now totals 150 million people. We must not assume that all of our modern conveniences were always available. Most of them are of recent origin and all have been improved in quality and lowered in price. Our nation is only 160 years old, actually only a moment in the passage of time. Dealing only with the essential items, it is important that we trace the industrial development which has occurred during that period and its influence upon the prosperity and living standard of our people.

Phenomenal Progress Under Private Enterprise System

In 1800 George Washington had completed his two terms as President. John Adams was completing his single term and in the fall of that year Thomas Jefferson was to be elected. Our country was comprised of the thirteen colonies, located along the Atlantic seaboard and extending from New Hampshire on the north to Georgia on the south. The population of the country was 5,300,000. Florida was owned by Spain, Louisiana by France. After the Louisiana Purchase in 1803, this territory, which extended from Canada to the Gulf, lying west of the Mississippi River, was divided into nine of our present states and some parts of four others. Texas, New Mexico, Arizona, California, Utah and Nevada were all acquired later from Mexico.

Transportation and communication were practically the same as they had been in the time of Christ, some two thousand years before. James Watt had developed the steam engine and had taken out patents in 1775. But up to 1800 it was used exclusively for pumping water out of the mines in England.

During the next 70 years the country developed and expanded, taking in most of the territory we now look upon as representing the United States. The population increased to 38.5 million people. There were relatively few inventions in that time in relation to what we know today, although those that were made were extremely important. Steam was applied to both water and rail transportation and was used, to a limited extent, in supplying power in factories. However, the power had to be transmitted to the machines through line shafting and belting and was, therefore, not adaptable on a wide scale.

The principal inventions were the vulcanizing of rubber by Goodyear in 1839. In 1844 Morse sent the first telegraphic message, in 1851 Daguerre developed the first sensitized photographic plate. In 1866 Cyrus Field laid the first Atlantic cable and in 1867 Pullman invented the sleeping car.

During the next thirty years, ending in 1900, our population increased to 75 million people and the inventions of that 30-year period exceeded in importance all that had been made in the prior centuries. The living conditions which we accept as normal today would not have been possible without them.

In 1876 Alexander Graham Bell invented the telephone. In the next year Edison invented the phonograph and in 1879 the electric light. Then, in the ten years between 1880 and 1890, the world was given two new forms of manufactured power—the electric motor and the internal combustion engine. From the beginning of time up until the invention of the steam engine by James Watt, the only forms of power were the energy of man, beast, wind and water. Steam rendered a limited source of energy for a period of 100 years and then, within one decade, we developed two new forms that have completely revolutionized industry and our civilization.

In 1893 the kinetoscope, the basic in-

vention of the motion picture, was developed by Edison. In 1894 Roentgen invented the X-ray and in 1896 Marconi invented the wireless telegraph. These were the outstanding inventions during this period of thirty years.

It is difficult to realize the progress that has been made in transportation, communication, manufacturing, distribution and industry during the past fifty years and in this progress engineering has played a very important part.

Our aviation industry represents the greatest progress in transportation. On June 10th of this year a Detroit paper carried an interesting column in which the author described her experience in boarding a plane as the sun was rising over Paris, stopping at Shannon and Gander and arriving at Willow Run Airport in Detroit one hour before sunset. Paris to Detroit in the daylight hours of a single day! Let us look back to December 17, 1903.

On that date the Wright Brothers made the first successful mechanically powered airplane flight at Kitty Hawk, North Carolina. They made four such flights. The first lasted twelve seconds, the second and third were longer, while the fourth lasted fifty-nine seconds and covered 853 feet against a twenty-mile headwind.

Compare 853 feet in 59 seconds forty-five years ago last December with the speeds of the supersonic jet-propelled planes of today—speeds that exceed 2000 feet per second. The improvement of the internal combustion engine by the automotive industry made the progress of aviation possible.

An important advance in communication has been accomplished by the telephone. In 1900 the telephone was limited in number of instruments in use as well as in distance over which it could be used. Now we can talk to any of the principal cities in the world and to most of the ships at sea. Adapting the principle of wireless telegraphy discovered by Marconi made this possible and was subsequently expanded into radio and television. Few people realize the first radio broadcasting station was opened in Pittsburgh in 1920, less than 30 years ago. We now have 75 million radio receiving sets in 40 million homes. Television is available to nearly 67 million people, even though it is relatively new as an industry. It was the investment of private capital and the intelligent management of industry that made this progress possible.

Since 1893 the motion picture industry has been developed to a point where there are 18,000 theatres with a capacity of 12 million seats. The employment made available through the production of cameras and film and in the distribution and showing of the pictures is another illustration of the importance of investment of private capital.

The Automotive Industry

The automotive industry has shown the greatest growth and is responsible for the employment of one out of every seven workmen. This industry started with the building of the first successful internal combustion engine in 1887 and its application to the first gasoline powered automobile by the Duryea Brothers in 1893. The number of vehicles produced prior to 1900 is not known as no records are available. Production in 1900 was 4,192 units and in August, 1948 the industry produced the 100 millionth vehicle.

Where the risk is great the opportunity for profit must be equally great to attract the required investment of venture capital. Since 1900 more than 1850 different automobile producing companies entered this highly competitive field and today there are 54, a mortality rate of 97 per cent.

General Motors has been specifically referred to by the Committee in Washington and on the floor of Congress. We who are associated with General Motors are proud of its record, its size, and of the contribution it is making to a better living standard of the nation. While complete annual statements are issued,

there are essential facts that should be stressed.

General Motors is best known for its production of passenger cars and trucks, but it also produces 750,000 fractional horsepower electric motors per month, refrigerators, radios, washing machines, diesel electric locomotives, approximately 70 per cent of the aviation jet engines produced in this country, and many other products. We employ nearly 400,000 people, buy from 12,400 sources of supply, sell to more than 16,000 automotive dealers, plus thousands of outlets for our other products. The company is owned by 430,000 stockholders who have invested two billion dollars in the business, including the 125 million borrowed from the insurance companies and for which the stockholders are liable.

The size of General Motors has been determined by the desire of our customers for the products we make, and our desire to satisfy consumer demand. Our sales at wholesale in 1948 were 4.7 billion dollars. The dealers, and their more than 200,000 employes, resold these products at retail.

General Motors purchases of material and services exceeded 50 per cent of our sales, a total of $2,368,000,000, a large part of which was supplied by small business concerns. Big business could not operate without the support of small business, and small business could not survive without selling to the large concerns.

Wages and salaries cost $1,343,000,000. Incidentally, the entire General Motors payroll for 1948 was equal to the Federal Government payroll for the month of October, 1948. It causes us to wonder what the senators mean when they refer to the need of control of big business. Taxes were 694 million dollars and that left 440 million in profits for the stockholders, of which 211 was paid in dividends and the remainder of 229 million was reinvested in the business.

To clearly understand the result of General Motors operations for 1948, these figures should be related to each other. The stockholders who own the business and furnish the money that makes the enterprise possible, and who also assume all risk of financial loss, received an aggregate of 211 million dollars in dividends and their equity in the business was increased by 229 million of reinvested earnings, a total of 440 million.

Federal, State, County and City tax authorities collected 694 million dollars, more than 150 per cent of the amount earned for the stockholders, and more than three times the amount the owners received in dividends. Payrolls were three times the total stockholders earnings and six times the dividend payments, yet General Motors was called to Washington to testify as to its prices and profits, and told that its size "poses problems with which this Congress will ultimately have to deal in ways I cannot foresee at present."

Let us clarify the stock ownership of General Motors, and its experience is typical of most industrial corporations. There are 140,000 stockholders who own 10 shares or less of General Motors stock. There are another 180,000 who own more than 10 and less than 50 shares. Of the remaining 100,000 stockholders, many are insurance companies, investment trusts and charitable organizations, in which many people have an interest. In other words, big business is a combination of a great many small people who have joined together to make an investment, and these small investors have the benefit of the wisdom, business experience and management capacity just the same as the heavy stockholders. They are participating in all the benefits in proportion to the number of shares they own.

Government is Discouraging Industrial Expansion

The present attitude of Government toward Industry, together with excessive taxes, has discouraged the investment of savings as venture capital. It is difficult for large concerns with a good earn-

ing record and proven management to secure new capital or long term loans required to meet the expanding needs of the business. In speaking of Governmental attitude, I do not distinguish by party, Republicans, Democrats, New Deal, Fair Deal or Dixiecrats. I am referring to political expediency and honesty in political administration.

The expenditures of our Federal Government from the inauguration of George Washington on March 4, 1789 to the end of 1918, a period of 130 years, were 41½ billion dollars. This included the cost of the war of 1812, the Mexican War, Civil War, Spanish-American War and the years of 1917–1918 of World War I. Our present administration is requesting 42 billion dollars for the next fiscal year, and World War II has been over nearly four years.

Following World War I the Federal Budget averaged less than four billion annually, one-tenth of the present level. In those years the Government had 560,000 employes, now it has 2,100,000.

There is currently before the Congress a proposal to spend 10 billion dollars for socialized medicine. Another proposal is a farm program which will cost 10 billion dollars. Then there is a bill providing for the expenditure of 20 billion dollars over a twenty-year period for Federal Housing. I am convinced that the amount, if the bill became law, would be substantially increased and the period of expenditure would be reduced. In each of these cases the group that would benefit would have to sacrifice their freedom in order to participate. The farmer would have to agree as to the type of crop he would plant, acreage to be planted and to comply with price regulations when marketed. The Government has established a routine of confiscating our savings by excessive taxation and buying, with our own money, certain voting segments.

The following statement by General Eisenhower in reference to the bill for Federal aid to Education sets forth the danger we face in all these cases. General Eisenhower said, "Unless we are careful, even the great and necessary educational processes in our country will become yet another vehicle by which the believers in paternalism, if not outright socialism, will gain still additional power for the Federal Government. The army of persons who urge greater and greater centralization of authority and greater and greater dependence upon the Federal treasury are really more dangerous to our form of government than any external threat that can possibly be arrayed against us." General Eisenhower is entitled to the thanks of the country for drawing attention to the danger of central control, which has already progressed to a dangerous degree.

I am particularly gratified to have a place on your program and for the opportunity to speak frankly to you on this subject of mutual interest. You have an extremely important assignment in the education of 240,000 young people who have chosen the engineering profession for their life work. They are being trained under your supervision. Unless industry can successfully expand and develop in the future as it has in the past, these young people will have little hope for the future except as replacement for older people and your work will have been futile. Your interests and ours are parallel. We are interested in the welfare of our country. We want our economy to grow and expand and this nation to be a good place for our children, and our children's children, as it has been for us.

Popular Reactions

Recent happenings have indicated the power of an aroused voting public. The passage of the Reorganization Act of 1949 came as a result of a flood of letters, telegrams and ballots that were sent to the Congress. The same result can be secured in respect to taxes if similar demand is made.

Referring again to our experience in Washington last December, the question

was directly asked as to our recommendation as to sources of additional tax revenue to permit continued governmental expenditures at the prevailing levels. Should normal rates be increased, excess profits reestablished, or a graduated scale adopted for corporations similar to individual income tax rates? The implication was given that the November 21, 1948 election was a mandate from the people to continue the policy in effect.

In respect to taxes, no corporation pays a tax. All taxes are paid by people. If a corporation fails to recover all cost, including taxes, in the selling prices, they are distributing their capital with each sale, and if continued long enough and on a sufficient number of transactions, the concern will be liquidated. It should be obvious, therefore, that taxes imposed on corporations are passed on to the customers or borne by the stockholders, all of whom are people.

The last election was far from a mandate. There are 94 million people in this country who are eligible to vote. Sixty-seven million of them registered, 48 million voted, and 24 million voted for the incumbent administration. When the electorate of this country does not like the wasteful extravagance of Government they will change it by demanding a reduction of taxes and a return to the principle of free enterprise that made this country great.

Our task, and our responsibility, is to place before the people a clear understanding of the prevailing trends. There are 92 million people in this country who were not born or were less than 21 years of age when Franklin Roosevelt was inaugurated in March of 1933. They have never known any type of Federal administration except Federal control.

I am convinced that many people will feel that the things I say—and what is being said by most industrialists—are self-serving. After all, it is my country just as it is yours and I have a perfect right to express my opinion. I want to thank you for having had the patience to listen to me.

Professional Guide for Junior Engineers

This 56-page publication, issued by the Engineers' Council for Professional Development, was written by the late Dr. William E. Wickenden, and edited by G. Ross Heninger.

The book seeks to give the young engineering graduate a sense of professional values in chapters on engineering origins and professional relationships. Full treatment is given to the practical side of getting an engineering job and of advancing in the profession. Also included is the Council's credo "Faith of the Engineer," a self-appraisal questionnaire, and the Canon of Ethics for Engineers.

The price is $1.00 per copy (25% discount on 10 or more copies). Send orders to Engineers Council for Professional Development, 29 W. 39th St., New York 18, N. Y., and enclose remittance.

Problems of Training the Engineering Student for Citizenship[1]

By CHARLES E. MacQUIGG

Dean of Engineering, Ohio State University

For the purpose of the present discussion the personal qualities required for good citizenship are assumed to be: first, character; second, intelligence; third, competence in the line of contribution to the material welfare of society. These are placed in their proposed order of importance. It is the present purpose to discuss the first criterion only and for that reason it is proper to first dispose of the second and third.

Intelligence is here defined loosely as the quality believed to be chiefly a matter of inheritance and as a fundamental quality of personality about which little can be done. It may be that this viewpoint will be very offensive to the behaviorist and a final decision must be left to more competent authority; in any event, it is assumed that little can be done to add to the sum total of the intelligence factor of personality in a college education. We do, however, add to the effectiveness of an intelligence by processes which aid the acquisition of useful facts, and to that minor extent we do make some contribution.

The attribute of competence is taken to mean the skill and experience of the individual and these naturally integrate into his other qualities to make him a more desirable and productive citizen. These factors seem to be too obvious to require elaboration; moreover, it is generally believed that the educators of the engineer have done an acceptable job in this area, or at least as good as may be expected taking due account of the attributes involved in faculties and students. (Lest we fall into any kind of smugness on this score, however, we must continually examine our curricula and staff, making every effort to utilize all of the machinery of teacher training (including personality assays); visual aids, and any other ways to increase our efficiency.)

Character Development

Dismissing thus two of the three assumed attributes of good citizenship, what of the third, namely character, and what if anything can the engineering teacher do to help his students in this primary requirement of citizenship? Can we assume that character can be molded any more than we can believe that the intrinsic quality of the intellect can be raised? I think we can so believe. But let us first define what we mean by character. It is "A trait or characteristic, especially one serving as an essential or inner nature of an object or person." "That which a person or thing really is." "Moral vigor or firmness, especially as acquired through self-discipline." "Character endures throughout defamation in every form, but perishes when there is a voluntary transgression." In other words, character sums up those qualities of the spirit of the individual which shows in the types of action he exhibits—such as steadfastness, sobriety, liberality, cheerfulness, truthfulness, charity, and many others—with, of course, their opposites.

[1] Presented before the Humanistic-Social Division at the 57th Annual Meeting of the ASEE, Troy, N. Y., June 21, 1949.

It might appear to many that by the time a student has reached college age his character will be formed, but this is true only to a certain degree since most of us know of many exceptions and if we are frank, we realize the truth of this observation in our own experiences.

If we consider that the youth we are privileged to influence are still somewhat plastic, as it were, what is to be done? This brings up the necessity for being aware of and sensitive to the problems youth is facing on the average campus. No one can deny that the pressure of living has increased in the past two or three decades to levels beyond anything previously experienced in human history and the youth of today is beset by worries not experienced by mature men of fifty years ago. If the nature of the problems has not materially changed their insistence certainly has and also the tempo of their insistence. So, in touching upon a few of those college problems of today (which are equivalent to if not identical with those of John Q. Citizen) let youth speak for itself.

Survey of College Problems

A very recent survey at one of the large universities was made by questioning 601 men and 157 women students comprising those with various degrees of college experience—i.e., direct from high school; from high school via intervening work experience; and some by transfer from other colleges. About one-third were veterans with postwar short enlistments. A number were married and had children; most wives were working. The questions asked were chiefly along the lines of "adjustments" and embraced such areas as health, scholastic, financial, family and home, religion, moral, personality, social (such as friends, leadership, recreation, fraternities, etc.), living conditions (rooms, food, community relationships, etc.), outreach (cultural, hobbies, life plans, etc.). The survey showed the following:

Health generally good; need for keeping physically fit was generally recognized; food was a problem; worry and nervousness over studies, "tired feeling," loss of sleep, loss of weight were complained about; student Health Service was used.

Scholastic adjustments were quite severe. Large classes a special problem and consequent loss of individuality was a shock to many. Inability to take adequate notes was a severe handicap. In spite of these transitions, the consensus was not critical of the instruction; surprise was expressed at the efficiency of the teaching staff in general. There was a general feeling of surprise at the responsibility put on the student to "be on his own." [2] The problems of study facilities were noted as acute in dormitories, and ideal conditions noted in private homes. Grades are always "going to improve next semester."

With respect to finances, almost invariably the students find expenses heavier than planned for. Modes of living have to be adjusted to pocketbooks. The majority of all students and most of the women were entirely supported by parents; there is a feeling of nearly universal regret among the students at this dependency. Most veterans cannot live on their subsistence checks and in general the wives are working. Outside employment shows a high incidence with occupations varying widely—common laborers, bartender, skilled accountant, etc., etc. Outside work is frequently blamed for low grades and lack of participation in extra-curricular activities.

Social adjustments. Students living at home found little change—life going on pretty much as usual. Students away

[2] Information from C. W. Reeder, Junior Dean, College of Commerce and Administration, The Ohio State University. In the last analysis, isn't the success of a college student determined by his general ability to take over on his own responsibility? Those who learn this, if they have average mentality, will get through, but those who lack this ability will almost surely fail.

for the first time noted a marked difference in the imposition of the factor of "self-government." Week-ends at home are generally to be deplored, no matter what the excuse. Jewish students exhibit the closest ties with home. Veterans as a class are the most emancipated group; college is for them a continuing incident in life away from the parental fireside. Marriage greatly increases all responsibilities. Almost universal mention was made of the interest of parents in the children resulting in frequent letters and long distance phone calls.

Religious and Moral Standards

It was reassuring to learn that college life apparently introduces very little disturbance to religious backgrounds with little or no change in beliefs and denominational preferences. Jews and Catholics are most firmly rooted in their religious preferences with Protestants observing a "live and let live" attitude. Discussions on religious subjects are frequent and often heated, with little change of stand resulting. These debates give rise to an interest in religion and some students have been stimulated to visit other churches to get firsthand information. Church going is not the rule, the excuse being that Sunday is used for sleep. "Some comments were made concerning statements of University teachers. Some faculty men belittle religion, but others teach tolerance. Some show the relation of religious teachings to their subject fields. Many students said that their growth in knowledge had not changed in any way their religious beliefs."

Respecting moral standards, most students follow the patterns they learned at home, and college life gives them small reason to vary their standards. A tendency is greater among women than men to miss counsel of their parents. Such criticism as was noted was directed against behavior at social parties, particularly drunkenness.

Other Factors

"Students found it hard to discuss their own personalities. Some did note changes which had occurred under impact of University experience. The most common observation was the growth in independence. There was the need to make decisions on many matters, and no one to consult. Pleasure was expressed over the development of this characteristic."

Fraternities were praised for their improved living and study conditions over dormitories; social graces and ability to mix successfully were noted as advantages by those who were members. (Might some "unscrupulous" educator make a sly argument for broadening?) Criticism of fraternities was from nonmembers and was chiefly on account of the expense and social excesses.

"The students were very frank about their plans for marriage. No one, neither men nor women, planned to live alone. All look forward to homes and children. But all wanted an income sufficient to maintain a decent standard of living."

These are some of the problems that confront the students of today. What can the teacher in the college of engineering do, if anything, to help guide these young people who will make the society of tomorrow?

So much cogent advice has been spoken and written in the past few years anent the inclusion of the humanistic studies in the education of the engineer that further reference here would be mere reiteration. In this area we have a right to expect the best results in the broadening, enlightening and orientation of our students toward the implications of good citizenship; this orientation can come from the study of history, philosophy, sociology and similar disciplines. These fall outside the scope of the technical, but it seems that the teachers of technology have a duty and, what is more important, an opportunity to influence their students in as effective a way as do the teachers of the humanities.

Counseling Needs

There are many excellent reasons why few engineering faculties will be able to enter into any *formal* plan for the counseling and advisement of students in other than purely technical matters, the chief one being lack of time. But if the faculty member is aware of the adjustment problems of the students and is at the same time sympathetic and willing, the following are some of the ways in which aid may be extended:

1. Realization of his responsibility. Dr. Wickenden realized this in his philosophy of "The Second Mile." In counseling students, one repeatedly finds an element of wistful wishing on the part of the student that he might have been able to have had advice from a teacher at some critical time or other which might have helped him avoid a difficulty. The teacher in any subject who does not try to meet this need by making the real sacrifice of nervous energy entailed had better find another occupation.

2. Lack of sympathy on the part of any teacher seems to be the "unpardonable sin" from the students' viewpoint. Students may chafe under hard driving; high but difficult standards of performance may not at the moment be welcomed (although they are almost invariably recognized in later years and commended). But cynicism and sarcasm are always resented and never serve any useful purpose; even after long years of maturity the habitually sarcastic teacher is remembered as one who failed his objective even in an educational sense.

3. At this time in world affairs, an attitude of hopefulness is needed and we need not fear that our discriminating students will mistake it for narcosis on the one hand or naiveté on the other. If one of two choices were necessary, rather than sell this country and all humanity down the river of despair, it were better that we fall back on the philosophy of stoicism. But neither choice is alternative if we realize that most of our gloomy outlook at present stems from a rather personal selfishness. Just now we should compare the obvious good of today with the manifest ills of yesterday. Man has changed a little for the better in thousands of years, so give him time! What skeptic among us would go back even twenty-five years and trade *everything* in that day for life today?

4. No single one of us lacks frequent opportunities to advise with our students in an effort to reach a citizenry with reasonable optimism, with charity and justice, with tolerance, with always greater incentives to mutual helpfulness and a living desire to see the greatest good to the greatest number.

5. The students themselves are concerned about problems of ethics. Many of us may have opportunities to counsel groups on misconduct in examinations, on intemperance in social gatherings and other irregularities to which we cannot close our eyes and which are so obviously the actions of the few but by which the public measures the standards of the many. A leaven of wise counsel to fortify the resistance of the majority of upright student opinion will surely pay off in our future citizens.

These are some of the ways in which the teachers of descriptive geometry, or electronics, or English, or thermodynamics can help to prepare the engineering student for citizenship.

Efficiency and Cooperative Behavior[1]

By F. J. ROETHLISBERGER

Professor of Human Relations, Graduate School of Business Administration, Harvard University

Efficiency and Cooperation in Modern Industry

Modern industry presents an interesting contrast. On the one hand tremendous advances have been made in the application of science and technical skill to the economic purposes of business. Scientific controls have been introduced to further the practical purposes of industrial organization. Operations have been logically organized to achieve more efficient ends. Much of this advance has gone on in the name of efficiency, and to this development engineering has contributed a great deal.

On the other hand, nothing comparable to this advance has gone on in the area of human relations. Our capacity to work together has not improved with our advance in material efficiency. Matters of morale and cooperation in our modern factories show no great improvement from what they were 50 or 100 years ago. Whatever slight advance there may have been is completely overshadowed by the new and powerful technology of modern industry. Our social skills have not advanced step by step with our technical skills.

This striking contrast between technical efficiency on one hand and matters of human cooperation on the other presents the number one problem of our present industrial civilization. It is obvious that we know a great deal more about machines than people. The technical skills of modern technology can be made explicit and communicated. To them science has been applied. Our social skills, on the other hand, are largely personal, empirical, and intuitive. They are so rooted in tradition that they cannot be made explicit. To them science has been little applied.

It is my opinion that there is no way of dealing with this problem other than the way that all the sciences have taken. We need to know more about what happens to people at work, and particularly we need to have more first hand knowledge. In the field of human relations, as in other areas, there is no substitute for first hand knowledge. We need a knowledge of acquaintance with the facts of cooperative behavior and simple skills of dealing with them.

Once this road is taken—and we have not traveled on it very far—I have become more convinced of the following observations. I find little justification for the prevailing assumption that so long as we turn out goods efficiently of good quality and of low cost, matters of cooperation can be left to chance. I find little evidence for the popular beliefs that cooperation is a matter of logical and technical contrivance or a matter of verbal exhortation—something that can be willed into being by verbal persuasion or efforts of personality. I find that there are just as brute and stubborn facts that determine matters of cooperation as there are brute and stubborn facts that determine matters of technical efficiency, and I find that there are just as specific methods, skills, and a point of view which can be employed to ensure

[1] Presented at the annual meeting of the Ohio Section at Ohio University, Athens, Ohio, April 9, 1949.

cooperation as there are equivalent tools for ensuring technical efficiency. To the relevant methods, skills, and point of view of dealing with the simple facts of cooperative behavior, I give the name of "human relations."

I want to consider two questions: (1) What do we know about the determinants of cooperative behavior and (2) how can we apply what we know? Let me begin by looking at the determinants of cooperative behavior first from the point of view of the individual.

Cooperative Behavior from the Point of View of the Individual

There is a widely held notion that people at work are primarily motivated by economic interest and that in their pursuit of economic gain they are essentially logical. According to this version the major inducement to cooperate is the factor of monetary return. Wherever and whenever this assumption has been seriously investigated in the light of facts, its universal validity has been seriously questioned. Investigator after investigator has agreed on this point. Far from being the prime and sole mover of human activity in business, economic interest has run far behind in the list of incentives that make men willing to work.

Although it would be incorrect to say that this oversimplified version of the economic motivation of people at work has been completely discarded, nevertheless in the past 25 years another picture has grown up with which it at least has to compete. According to this view, people at work are not too different from people in many other walks of life. Whether they work at the top or middle or bottom of an organization, they are not entirely creatures of logic; they too have feelings. For example, they like to be praised rather than blamed. They do not like to have to admit their mistakes—at least not publicly. They like to feel important and to have their work recognized as important. They like to feel secure and independent in their relations with their superiors. Moreover, also, they like to express their feelings. They like to be listened to and have their feelings and points of view taken into account. They like to be consulted about and participate in the changes which will personally affect them. In short, they too like to belong and be an integral part of some group.

According to this version man at work is a social creature as well as an "economic man." He has personal and social as well as economic needs. Work provides him with a way of life as well as a means of livelihood. To understand his satisfactions and dissatisfactions at work, one has to understand the social as well as the physical and economic setting in which his work takes place. One has to understand the kinds of relationships he has developed or can develop with his bosses, his subordinates, his co-workers, as well as with other people and groups in the organization. One has to understand the opportunity for social development and for the satisfaction of needs these relationships afford. Within these relationships can his basic social and emotional needs be satisfied?

From this point of view, therefore, cooperation depends upon two factors: (1) the social needs of people and (2) the opportunity which the environments offer for the fulfillment of these needs. This point of view, it should be noted, forces us to look as carefully at the social as at the material environment of the worker. It forces us to look at his social as well as his economic needs.

Two Basic Needs of People at Work

Any attempt to clarify the needs of people is admittedly an arbitrary one for the sake of convenience. I merely want to point out two very basic needs which often are in conflict.[2] On the one hand we want to be liked and approved of. We want to be able to do those things

[2] See Nathaniel Cantor, "The Dynamics of Learning" (Buffalo, Foster & Stewart Publishing Corporation, 1946).

which give us a sense of belonging. This need to belong and to be an accepted member of a group is very important and necessary for all of us. On the other hand, we also all want to be independent and express our own differences. We want to do things in our own way, to express our own unique feelings, to be ourselves in order to maintain our own feelings of self-esteem.

These two needs—for dependence on one hand and for independence on the other—are often in conflict. Too often we want our cake and eat it too. We want the approval of others and the sense of security which such approval gives us. At the same time we want to tell people off—we want to tell them "to go to hell" and yet fear the loss of support which such behavior might engender. It is obvious that if these needs are out of balance, the feelings they manifest do not make for cooperation. In modern industry, I find this conflict fairly acute. Too many people are in the position of wanting to tell their bosses to go to hell and yet are afraid to do so. (In this connection it should be noted that the union often offers a socially accepted form of expressing some of these feelings.)

Now, although many psychologists would have us believe that the resolution of this conflict can only be achieved by a better understanding of ourselves, I should like to turn to another aspect of cooperation before we reach this conclusion. Let us look at cooperation not only from the point of view of the individual, but also from the point of view of the group.

Cooperative Behavior from the Point of View of the Group

People at work are related to each other in many different ways, many of which are not represented in the organization chart or manual. Not only are they organized in terms of the technical requirements of the job, but also they are organized in terms of sentiments, social customs, codes of behavior, status, friendships, and cliques. In their daily associations together, people at work tend to develop routine patterns of relationships and social codes of behavior. They come to accept these patterns of behavior as obvious and to react as they dictate. Within this system of relationships each task performed has a rank in an established prestige scale. Each work group becomes a carrier of social value. Each job has its own social values and its rank in the social scale. Each worker has a social as well as a physical place in the organization.

In any coordinated human activity, people belong to small work groups. It is in these small work groups that their meaningful associations and activities take place. It is only through their activities and associations in these small work groups that they become related to the larger total enterprise. In business each small work group has its technical and economic purpose in terms of which its members are formally related. But also, each of these groups has its own informal codes of behavior, its own norms of conduct, and its common ways of thinking. These common codes and beliefs not only provide important functions for the individual; they also provide an effective basis for cooperation. They have the effect of making each individual feel an integral part of the group. They bind people into routine collaborative activity. They give people a social place and feeling of belonging. They provide the framework for the fulfillment of human satisfaction. They give people a feeling of self-respect, of independent choice, of not just being cogs in a machine. Far from being a hindrance to greater effectiveness, informal organization provides the setting which makes men willing to cooperate. It is in this setting that man's needs for dependence and independence can be brought into working balance.

It should be noted that these manifestations of informal organization are spontaneous phenomena which arise wherever coordinated human activities exist. They

cannot be prevented because they are the product of man's inherent desire to be a part of and belong to a group. They are not logical in character because they are concerned with values, ways of life, and ends in themselves. They are those aspects of social life which people try to protect and preserve and hence they cannot be changed quickly.

The importance to people at work of these informal groups can best be seen in relation to the introduction of change, when new methods or standards are initiated, newcomers are added, someone is transferred, upgraded or promoted. Any supervisor knows the time it takes for such groups to accommodate to such changes. Any change which can be regarded as an interference to their customary routines and personal interrelations is viewed with alarm and suspicion. Although these informal groups appear at all levels in the organization, the character of these groups in modern industry at the bottom of the organization is peculiarly significant, because, at this level more than at any other, the ways of life of these groups are constantly in jeopardy from technological changes, new methods, raised standards, and manipulation of one kind or another. As a result, these groups in industry take on a highly defensive and protective character. Their major function becomes unfortunately the resistance to change and innovation, and the codes and practices develop at variance with the economic purpose of the enterprise. These defensive and protective characteristics of many informal groups at the work level exist full blown in many factories, even before any formal union appears.

From the point of view of group behavior, then, cooperation, far from being a matter of logical and technical contrivance, is much more a product of relationships involving feeling and sentiment. Far from being something which can be willed into being by legislation, verbal persuasion, and efforts of personality, cooperation can only take place within the framework of established and accepted social structures. It is not something which springs up overnight, something which is here today and gone tomorrow, something which can be put into a group from the outside. Cooperation is dependent upon routine relationships developed and practiced over a long period of time. It is dependent upon codes of behavior by means of which people work together in a group without any conscious choice as to whether they will or will not cooperate. It is dependent upon a certain stability in the ways of life of groups. Only under these stable social structures can peoples' needs for achievement, security, independence, participation, status, and growth be realized.

Cooperative Behavior from the Point of View of Modern Technology

So far I have looked at cooperation from the point of view of the individual and his feelings and needs. I have also looked at cooperation from the point of view of the group and its social codes, routines, and sentiments. In each case I have wanted to show that cooperative behavior is a product of feeling and relationship. In essence, it is not something logical in character.

Let us now look at cooperation from the point of view of modern technology. From this point of view industry is not primarily organized to ensure cooperation. It is primarily directed to the production of goods of good quality at low cost. But more than this, modern industry is no longer turning out customary products in customary ways for customary customers. It is committed to turning out new and different products in more efficient ways and at lower costs for more quality-and-price-conscious consumers. To this end science and technology have committted themselves, with the result that the environment of the modern factory is quite different from the old know-how shop. In the modern standard shop there are a large number of people whose sole purpose is to originate better ways,

more efficient and less costly ways of doing things, as well as to devise standards and controls to see to it that these goals are secured. The far-reaching repercussions of their activities for the social organization of industrial concerns is serious. Introduced without awareness of their effects upon the informal social organization, these activities can easily (1) dislocate people, (2) interfere with their established ways, (3) break up work groups, (4) prevent the development and practice of routine relationships, and (5) produce feelings of anxiety, insecurity, and frustration—what is often referred to as the feeling of being "pushed around." In short, the logical organization of efficient operation can operate against the social organization of teamwork. Many of the changes modern technology originates can collide head on with the social organization of the company and its attempt to maintain internal stability—a necessary precondition, as we have seen for cooperative behavior. With the very best of intentions, modern technology can unwittingly foster the segmentation of the social structure of industry into groups with radically different points of view. It can unwittingly assist in the development of rigidities of relationship between segments of the structure that make cooperation difficult, if not in some cases impossible. The patterns of behavior produced by modern technology do not in and by themselves make for cooperation.

Cooperative Behavior from the Point of View of the Executive

So far we have been looking at cooperation from the point of view of the people whose cooperation is being sought. Let us look briefly at cooperation from the point of view of those who are trying to secure it. It is one of the functions of the executive to secure the understanding of people to the purposes of the organization. How does he do this? According to one version the executive gets things done through the authority of his position and the clarity of his communication. How these assumptions came about, I do not know because so far I have found little evidence to support them.

Most of us know people who, with all the formal authority in the world and with an unusual capacity to express themselves logically, have great difficulty in getting cooperation. Likewise, many of my more inarticulate friends in positions of little formal authority seem to have no difficulty in securing the understanding of people. It has frequently been noted how some people lose what little authority they have by issuing orders they know cannot or will not be obeyed. Authority does not reside in the superior individual; it resides in the kind of relationship the superior has developed with his subordinates. Without the cooperative attitudes of subordinates, the voice of authority can speak, but the big booming voices it makes do not register upon people.

An extraordinary blindness to this point about securing the understanding of people is well manifested by what I shall refer to as the "tell-'em, sell-'em, explain-it-to-'em" school of thought. Whenever situations arise where people are reluctant to follow or accept cheerfully certain management orders, policies, changes, goals, aims, or what not, this school of thought immediately assumes that this state of affairs exists only because the people involved do not logically understand the need for the order, change, new objective, or what not. This school of thought assumes that a clear order is automatically always obeyed; that the logical and lucid exposition of an aim is sufficient for people to accept it; that any change is cheerfully accepted when the need for it is logically understood. As a result, all problems relating to the securing of people's understanding are resolved by the "tell-'em, sell-'em, explain-it-to-'em" technique. People are told most solemnly how their rates of pay have been determined, how and why this is the best method to do

their work, why this is the best company to work for, etc. Whenever this method fails and people still don't understand all that is told them, this school of thought, being unable to question its assumption about matters of human understanding, is forced into either one of two conclusions: (1) "These clucks are just too damn dumb to understand," or (2) they still have not been clear enough. In this latter case they continue feverishly to draw more charts and diagrams, prepare more manuals and bulletins, and hire more experts in communication to explain policy in words of one syllable, so that this time even a moron will really understand management's good intentions and purposes.

The Case of Mary

In this connection I can think of a young married woman, whom I shall call Mary, who was hired for temporary work by an office manager for a temporary job and because it was against the policy of the company to hire married women for permanent employment. When Mary was hired she was told about this policy, and six months later when she was told that her services were no longer required, she was again reminded about the policy of the company against the permanent employment of married women. Because her work had been of good quality, the office manager even gave her two weeks' advance notice and two weeks' advance pay. At this point, Mary, instead of being appreciative, began to accuse the office manager and the company of giving her a "raw deal." She told her story to many people; how she had been allowed to stay on for six months, how during this period another person had been hired, and why therefore she shouldn't be the one to go, etc. The assistant manager, the office manager, with the credit manager all reasoned with Mary unsuccessfully. They told her over and over again about the company policy regarding married women. But she would have none of it. Before she left she succeeded in raising such a rumpus that she finally got the attention of the president of the company. The poor office manager was bewildered and hurt at Mary's unreasonable response.

Although we can all sympathize with the well-intentioned office manager, the interesting point in this situation is that what Mary was told and what Mary heard were two quite different things. People are more likely to hear things in terms of their feelings and personal situation. Mary was the sole support of an unemployed husband and a child—a fact which the office manager, when hiring Mary, did not find out. Temporary work, therefore, was no solution of Mary's personal problem. If the office manager had talked to her about that before hiring her, or at least during the six months' period of her employment, she might have heard what he said. But he was trying to get her to understand the policy of the company. In this process he was crystal clear, but in terms of Mary's situation and her feelings of permanent status after six months' employment, it was certainly the last thing Mary was capable of hearing.

This instance may be trivial, but it illustrates simply the futility of trying to explain things to people merely in terms of the speaker's point of view and without taking into account the point of view of the person to whom the explanation is being given. This approach assumes that people emotionally accept what they logically understand. It refuses to accept the fact that people are motivated more by matters of feeling and sentiment than matters of fact and logic. No amount of logical explanation from management's point of view will be emotionally accepted by people if it fails to take into account their personal situations and feelings. It only provokes argument and irritation—a feeling of being misunderstood.

Effective communication between superior and subordinate generally starts with listening on the part of the superior

and in trying to understand what the subordinate means within his own frame of reference before the superior starts talking. And when the superior does talk, he is more likely to be understood if he addresses himself to the needs and feelings of the subordinate as well as the purposes of the organization.

What Skills Does the Executive Need?

If my analysis is correct, modern industry needs more executives trained in more explicit skills of securing understanding and cooperation. The complex social system the executive has to administer requires more explicit human relations skills. If the intuitive and traditional ways of handling our human relations no longer work, what are these new skills the executive needs? Can we specify them more clearly?

Inasmuch as these skills are closely related to the phenomena I have been describing, I have already indicated my answer in part. From what I have already said about the nature of cooperative behavior, it should be clear that the practitioner of these skills has to be oriented in the following manner:

1. He has to address himself to what is important to people from their point of view as well as from his own and to make sure he does not confuse the two.
2. He has to address himself to people's feelings, attitudes, and personal background as well as to their more logical motives and purposes.
3. He has to look at the relationships people have with one another from the needs of individuals these relationships satisfy, as well as from the more logical purposes that are secured through them.
4. He has to think in terms of organic rather than mechanical analogies.
5. He has to be clinically, rather than merely logically, oriented.
6. He has to have a capacity to size up total situations and responses to them.
7. But more than practicing these skills of diagnosis, he also has to practice skills of communication and action. He has to develop a skill of helping people to feel secure, to learn from their own experience, to reach their own decisions, and to become more mature and independent.

I hope that these very brief statements will help to convey in a very general way the nature of these human relations skills. But I would be very remiss indeed if I did not point out to you that to specify these skills, though difficult, is not nearly so difficult as to practice them.

Can These Skills be Learned and Practiced?

The learning and practice of these skills are extremely difficult. About this there can be little question. The difficulty does not seem to arise because these skills are difficult to understand intellectually. Nor is it due solely to the fact that these skills, like any skill, have to be practiced in order to be learned, and that they cannot be learned merely from a text book. These difficulties are present, of course, but the blockage goes deeper than this. During the many years I have tried to practice and teach these skills, I have come to believe that the major difficulty arises from the uncomfortable feelings which the practice of these skills sets up in the practitioner.

As I have said, for most of us these skills are rooted in the personal, the intuitive, the customary, and the traditional. To make them explicit makes many of us uncomfortable and uneasy. It forces us to become more conscious of ourselves—our own attitudes and feelings—and how they affect what we do and say. It makes us conscious of our own unconscious manipulations. But more than this, the practice of this skill requires an emotional acceptance on the part of the practitioner of two propositions which often go against our traditional attitudes.

1. It requires a willingness to accept the importance and inevitability of nonlogical behavior.
2. It requires a willingness to see and appreciate points of view different from our own.

For most of us these propositions are difficult to accept emotionally. It is not difficult for us to understand that people are motivated more by matters of feeling and sentiment than by matters of fact and logic. It is not difficult to see that people are members of groups and act in accordance with the sentiments of these groups (which is all that I mean by non-logical behavior). But to practice this understanding is another matter.

It is obvious, for example, that we all do not perceive the world the same way. What is important to one person or group is not important to another. Matters that are of importance to management are not of the same importance to employees. Older service employees do not share the same values as younger service employees. What is important to professors may not have the same weight with students. And so on and so on. I shall not belabor this commonplace observation. All of us have had sufficient experience to realize that we do not perceive the reality quite in the same way as our parents, our teachers, our bosses, our wives, or our children.

It is also obvious that people respond to the reality as they perceive it to be and not as it actually is. Two workers may perceive their common boss in quite different ways. If worker A perceives his boss as a domineering individual, he will respond in terms of that reality; if worker B perceives this boss as a rather pathetic, insecure person, he will respond to that perception. It is very likely that neither perception resembles the perception that the boss has of himself nor the perception the boss's boss has of him.

But what makes the situation still worse is that although many people can understand these matters intellectually, they cannot accept them emotionally so that they can apply their understanding with any skill. The emotional acceptance of individual differences—our own as well as that of others—is a painful process of maturation.

How Can the Skills be Learned and Taught?

Because of the emotional difficulties in learning these skills, I have come to have a few simple ideas about a method of learning and teaching them. Some of the elements of this method, which I shall call the case method, I should like to call to your attention.

In this method of instruction we start with a "case," i.e., a simple description of what actual people said, did, and felt in a concrete situation. The student is asked what he would do in such a situation were he in a position of responsibility in it. Moreover, he is asked not only what he would do, but how he would do it—what needs to be done and how to do it. By stressing this latter half, the student is made to realize the difference, for example, between "being tactful" in general and what the particular tactful remark in this particular situation would be.

In the human relations area I cannot stress enough the importance of this distinction. Too often our solutions are merely verbal because we do not address ourselves sufficiently to how we are to accomplish what needs to be done in a concrete situation with particular people who have particular feelings, needs, and relationships. It is always easier to deal with the "average person" than a particular person in a particular situation.

In the discussion of this case, therefore, the student is forced to face up to the attitudes and feelings of different people in the case. He comes to see how the same situation may look different to different people and groups. He comes to realize that he has to take into account these feelings and attitudes as one of the important determinants of the situation

with which he has to deal. Emotionally he comes to accept the fact that these elements are just as brute and stubborn data as other aspects of the situation.

In the discussion of the case the student is also encouraged to express freely his own feelings and attitudes about the people and problems being discussed. Gradually in this way we hope that he comes to recognize his own feelings and attitudes and the important part they play in what he says and does when he tries to deal with a concrete situation. It should be noted that in this process the instructor does not try to change or evaluate the feelings the student expresses. He tries to get the student to recognize his attitudes; it is up to the student to change them if he wants to.

As you can see, this method also requires skills of the instructor. But the skills he practices—it should be noted—are of a piece with the skills he is trying to communicate. The student therefore learns by example. It is no use for the instructor to tell his students about the importance of feelings and sentiments in the behavior of people if in the classroom he ignores the feelings and sentiments of his own students. Somehow the communication does not quite register.

It should be noted this method is quite different from the "tell-'em, sell-'em, explain-it-to-'em" approach. It is based upon quite a different set of assumptions. It does not assume that knowledge is something handed down on authority and that the acquisition of such knowledge is educative in itself. Learning is not based upon the student's ability to hand back abstractions. Learning is not based upon the student's ability to answer questions which the instructor asks. To the contrary, the case method assumes that the learning process is different for different people. It assumes that learning cannot take place apart from the experiences, attitudes, and feelings of the learner. In the case method, therefore, the student is allowed to raise and answer his own questions—not the instructor's.[3]

The case method stresses the importance and subjectivity of personal experiences. Granted that people learn from their experience, it is a fact that people may learn the "wrong" as well as the "right" lessons from experience. People often generalize from too limited experience. Because of certain attitudes they may misinterpret their experience. They may not see the significance of their experience. Before they can learn some things, therefore, they have to unlearn "many things that ain't so." The case method, therefore, assumes that people have to be helped to learn from their own experience. This assistance is the instructor's chief role.

The case method further assumes that learning must start with "concretions" (not "abstractions"), with what we may call action-oriented situations at the "how-to-do" level. Not until the student obtains some intuitive familiarity with these "concretions" and confidence in dealing with them, can he begin the process of formulating adequate generalizations from experience.

It is by this approach that I feel we can in a small way begin to face up to some of the very difficult problems underlying the learning of these human relations skills.

[3] See Earl C. Kelley, "Education for What is Real" (New York, Harper & Brothers, Publishers, 1947).

From the *Bulletin* of the Machine Design Committee of the A.S.E.E. comes the philosophical observation:

"It ain't what we know that causes trouble; it's what we know that ain't so."

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1950 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President (2 years) .....

.....

For Treasurer .....

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Signed .....

Title .....

Institution .....

Date .....

Scientific Research, Future Naval Power, and National Security[1]

By THOMAS J. KILLIAN

Science Director, Research Divisions, Office of Naval Research

The imposing title of my talk is not my creation nor that of anyone in the Navy Department. It is part of an act of Congress which was signed by the President nearly three years ago. This was an act: "To establish an Office of Naval Research in the Department of the Navy; to plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of naval power and the preservation of national security." Thus does Public Law 588 direct the Navy to prosecute a vigorous broad research program adequate to meet the future needs of naval power and national security. This is a broad assignment since the Navy is the largest and most complicated technical organization in the world. It is the responsibility of the Office of Naval Research to ensure the scientifically strong Navy essential to the future of our naval power and national security.

To discharge a responsibility of this magnitude requires that the Office of Naval Research do much more than conduct a research program. All frontiers of knowledge in the scientific areas of vital interest to the Navy must be intensively pushed forward. Applicable discoveries arising from research must be quickly made available to not only the developmental agencies of all the Armed Forces, but to industry. A continuing survey of our scientific strength and vulnerability must be made. Our scientific research readiness will without doubt be as important in a future conflict as our immediate operational readiness.

Research Programs

The principal operations of the Office of Naval Research can roughly be divided into two classes—the basic and applied research programs underway in the laboratories operated by the Office of Naval Research and the fundamental research programs which the Office of Naval Research sponsors in the colleges and universities of the country. This latter program is the one most familiar to you and the one to which I will devote most of my time. First a brief word about the ONR operated laboratories.

The Naval Research Laboratory in Anacostia, D. C., is the largest unspecialized research activity in the military establishment. Total employment is approximately 3000 civilian personnel and 30 naval officers. Of the 3000 civilian personnel, approximately 1000 are professional, that is to say, scientists or engineers. This laboratory is essentially a civilian research establishment under Navy management and control. Approximately 20% of the laboratory's effort is devoted to basic research, with the remainder in applied research, development, evaluation and testing. This is in accord with ONR's principle that a certain amount of basic research is essential in all activities engaged in applied research and development work. It is a necessity if the vitality and creative thinking of the scientists employed there

[1] Presented before the ECRC at the Annual Meeting of the ASEE, Troy, N. Y., June 20, 1949.

are to be preserved. Dr. Bush has pointed out that unless particular care is taken to preserve basic work, it will be driven out by the applied.

The activities of the Naval Research Laboratory touch practically every field of physical sciences. The technical activities are divided into the divisions of chemistry, electricity, optics, metallurgy, nucleonics, sound, mechanics and three in radio. The latter exist because of the present concentration of the Laboratory in electronic fields.

The second large laboratory under the direct control of the Office of Naval Research is the Special Devices Center at Sands Point, Port Washington, Long Island. The research and development responsibilities of this center lie in the field of training devices and aids, technical evaluators, and human engineering. The fundamental objectives of the center are to train men more efficiently and to assist in the design of equipment so that it can be more readily operated. It is apparent that all naval armament and all military machinery in general should be designed with the capabilities and the limitations of the human being in mind so that the requirements for extremely complex training, which is expensive in terms of effort, of manpower and most of all of time, may be minimized.

The material bureaus of the Navy are responsible for the design, procurement, installation and maintenance of all ship and shore equipment. Each has under its control several laboratories and test facilities to assist in this difficult task. The Bureau of Ships, for instance, has six well-equipped laboratories with excellent staffs—The Naval Electronics Laboratory in San Diego, California; The David Taylor Model Basin in Caderock, Md., The Engineering Experiment Station in Annapolis; The Material Laboratory in the New York Naval Shipyard; The Underwater Sound Laboratory in New London, Conn.; and the Boiler and Turbine Laboratory in Philadelphia. The other Bureaus similarly have laboratories to assure that the Navy not only has the best equipment that science and industry can supply, but that the highest levels of performance are attained through proper installation and maintenance.

The third large activity of the Office of Naval Research is that of the Research Divisions located in the Navy Department in Washington. These divisions plan, guide and sponsor a huge university research program. The story of this program is exciting. It is the greatest peace time cooperative undertaking in history between the academic world and government. It is the story of an experiment of great significance to science and education. This comprehensive program contains approximately 1200 projects in about 200 institutions at approximately a $20,000,000 a year level. Nearly 3000 scientists and 2500 graduate students are actively engaged in basic research projects of great interest to the Navy. These projects, as you know, were not assigned by the Navy. The original proposals were initiated by the investigators and the contracts were made with their universities. In many cases, the financial contribution of the university equals or exceeds that of the Navy.

Post-war Developments

First, I would like to review some of the thoughts which guided the initiation of the program, then discuss briefly its present status. Finally, I will attempt to look into the future and in particular consider the relationships of this program with the proposed National Science Foundation.

In 1946, we were guided by four facts of great importance. The security and prosperity of this country depend upon its scientific strength. This scientific strength is sustained by the unpredictable but inevitable important results of basic research. Second, basic research is essentially a long-term, peace-time activity. It cannot be effectively conducted in a war-time crash development atmosphere. Third, during the past war, our store of

basic knowledge was exploited to the point of diminishing returns. We scraped the bottom of the barrel. Finally, we do not have basic knowledge essential to develop weapons and counter-weapons we urgently need now.

Conditions existing at the end of the war influenced the university program. The shortage of scientific and technical personnel was acute.

Another immediate problem was the disposition of the research facilities and centers of NDRC and OSRD. The transition to peace time involved conserving these facilities and equipment for the scientific advancement of the country. Europe's scientific activities had been almost completely dislocated. This was especially significant in fields where the principal creative work had been traditionaly centered on the continent. Thus, it was felt necessary to initiate work in fields which had received little or no attention in this country prior to the war. An example of this is the science of low temperatures, cryogenics.

Finally, we attempted to use the vast experience gained during the war in various techniques of accelerating investigations. These include group attacks of scientists of different traditions and backgrounds on one problem, new methods of attack on old problems, and the possibilities of new approaches opening fresh fields of research. Experience has repeatedly shown that in time of stress, scientists can bring their talents to bear in many fields outside of their specialities. Many of the great advances in microwave radar at the Radiation Laboratory at MIT were made by nuclear physicists. On the West Coast, great improvements in rockets and propulsion were the result of the joint efforts of astronomers, nuclear physicists and aerodynamicists.

Units in Research Division

Since the technical strength of the Navy is dependent upon the Nation's scientific well being, research was supported on the basis of the broad scientific needs of the nation. In addition to providing financial support, arrangements were made to use naval facilities and personnel. Naval ships, submarines, aircraft and rockets were used to carry scientists and instruments to regions where significant data could be obtained. The breadth and scope of the program may be realized through a brief mention of the various units of the Research Divisions. The Division of Earth Sciences consists of branches in Ecology, Geography and Geophysics. In this division, broad programs in oceanography, meteorology and earth physics are guided. The country's northernmost research laboratory, the Naval Arctic Research Laboratory at Point Barrow, Alaska, only a thousand miles south of the North Pole, is controlled by this division. The Physical Sciences Division is made up of branches in Physics, Nuclear Physics, Materials, Chemistry, Electronics, and Power. Close relationships between the branches of this division and others have facilitated cross-fertilization in various scientific fields. An obvious case is the use of radioactive elements in tracer techniques. The Materials Branch which uses the results of surface and solid state physics and chemistry in its daily work automatically stimulates this cross-fertilization. In the Mathematics Division, there are branches in Mathematics, Computers, Logistics, and Mechanics. Before World War II, applied mathematics was not fashionable in this country. The activities of the Mathematics Division has done much to raise the scientific level of this country in mathematical statistics, numerical analysis and computing devices. The branches of Physiology, Biochemistry, Microbiology, Biophysics, and Dental constitute the Biological Sciences Division. Under the Human Resources Division are the Human Relations, Psychophysiology, and Manpower Branches. Under these two Bio-Science Divisions, outstanding research facilities and teams have been established. The warfare research division is that of Naval

Sciences. Staffed by officers of combat experience and civilian technical personnel, it consists of four branches, Air, Armament, Amphibious, and Undersea Warfare. It studies, surveys and evaluates the implications of scientific and technical advances on naval warfare.

University Program

The university program is by no means entirely Navy sponsored. We have many joint projects with the Army and with the Air Force. In some cases, the contracts are Army contracts with ONR transferring funds to the Army, and in other cases, the reverse is true. For example, one of our strongest research centers is supported equally by the Navy, Army and Air Forces. This is the type of unification and positive coordination which really produces effective results. A very large fraction of the ONR program in nuclear physics and the applications of nucleonics and atomic energy, to biology and medicine is planned, supported and administered jointly with the Atomic Energy Commission. In this way the coordination of effort in fields of joint interest is automatic.

One of our problems is how to maintain the present vigor and strength of the university program. We feel that one essential is a bilateral flow of scientific personnel between the universities and the ONR staff and between ONR and the research institutions. A sizeable fraction of our staff in Washington is on leave of absence from universities. Similarly, we have ONR personnel on leave from Washington to universities or spending a fraction of their time in creative research.

One of the questions most frequently asked is that concerning our relations with a National Science Foundation should one be established. This problem has been given a great deal of thought. First, the Navy has always given strong support to the establishment of a National Science Foundation. Second, there is general agreement that the National Military Establishment, and the Navy in particular, should be allowed and encouraged to continue the support of basic research at approximately present rates. There will of course be changes in the program. Obviously certain of our research projects can and will be transferred to the Foundation. Precisely which projects cannot be determined at this time. Each must be considered as an individual case. Any transfer must be accomplished through mutual agreement with the Foundation, ONR, the university and the investigator. There are certain areas of the frontiers of science in which the Navy has a vital interest. It should continue to support basic research in these fields. I may mention a few as examples—hydrography and oceanography; underwater acoustics; electromagnetic propagation; mathematical studies essential for the improvement of fire control for operational analysis of computers and for logistics; human engineering; studies of the normal man in relation to his environment with particular reference to aretic, tropic, and other extreme conditions.

The basic research program has made available to the Navy the advice and counsel of many of the outstanding scientists in the country. It is my feeling that the Navy should continue to have available a complete and balanced group of consultants in the biological and physical sciences.

However, the fundamental philosophy of the Navy is that basic research, having no foreseeable goal, will inevitably from time to time uncover new discoveries of overwhelming benefits not only to the Navy, but to our whole industrial and national economy. This is the reason for the existence of the Office of Naval Research and the recognition of the relation of basic research to applied research and development. It is the reason for the existence of the comprehensive program of basic research which the Navy is supporting in the traditional sources of fundamental knowledge, that is in the universities of this country.

With knowledge of our economic and military strength, a potential aggressor can evaluate our vulnerability to various types of warfare and even project the probable course of a war. This actually occurred during World War II in the case of the French Maginot line. However, no one can estimate the capabilities nor the potentialities of retaliation possessed by a nation of great scientific strength. This scientific strength is insurance against war, not only through its potential threat of reprisals against aggression, but also in its great promise to alleviate and eventually remove the causes of war.

Thus, through scientific research, we can be assured of the strength of our future naval power and the preservation of national security.

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Planning Civil Engineering Structures[1]

By JOHN B. WILBUR

Head of Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology

Consultant, Fay, Spofford and Thorndike, Boston, Massachusetts

It is a privilege to discuss the planning of Civil Engineering structures with this group, because of my conviction that a consideration of the planning process merits an important place in our Civil Engineering educational programs. We hope that our engineering graduates will occupy useful places in society. We expect that some will become experts who excel in a particular technique or skill. We know that others will become leaders in the sense that they will guide the efforts of other people in coordinated activities. In preparation for these careers, we, as engineering educators, place great emphasis upon the ability of students to think clearly.

But to some of us, training in the ability to think clearly is somewhat synonymous with training in what we often refer to as analytical thinking. Let us then consider what is meant by analysis in thinking. Analysis, in its broadest sense, means taking a thing apart and examining the pieces in a systematic manner. Analysis in thinking consists of breaking a problem down into its parts. This is an essential process in attacking a problem. But in reaching decisions and in deciding what should be done in a given situation, the parts of the problem, after having been carefully studied, must be brought together again. This process of bringing the parts together is in some respects the reverse of analysis. It may be called "synthesis in thinking." It involves the synthesis of many factors, and the making of decisions as to what is best "on the whole," or "taking everything into consideration."

Synthesis in Thinking

Perhaps nowhere in Civil Engineering education do we have a finer opportunity to provide students with some practice in synthesis in thinking than in connection with the planning of Civil Engineering structures. And so I approach this paper with a dual enthusiasm: first, because I believe that the planning of Civil Engineering structures or projects represents Civil Engineering practice at a high professional level, and secondly, because training in such planning offers an ideal environment in which to inculcate in the mind of the student the over-all approach to problems based on synthesis in thinking that is so vital to the making of broad scale decisions and to creative engineering.

My subject this afternoon is the "Planning of Civil Engineering Structures." I hope you will forgive me if I interpret the word "structures" in a very broad sense. For my purpose, a structure means anything built by a Civil Engineer. It refers to a pavement or to a pipe line as well as to a building, or a bridge, or a dam. It refers to an entire project as well as to the separate structures that make up the project. Perhaps

[1] Presented before a joint meeting of Architectural Engineering and Civil Engineering at the Annual Meeting of the ASEE, Troy, N. Y., June, 1949.

my title should have been the "Planning of Civil Engineering Projects," or perhaps it should have been "Planning, from the Viewpoint of the Civil Engineer"—because my attention will be centered on the possibility of using the planning process as a device to aid students to develop the ability to synthesize as well as analyze in approaching the problems they will encounter during their careers.

The planning process, broadly speaking, involves three phases. Each of these three phases has as its objective the answering of one of the following questions: (1) What have we got? (2) What do we want? (3) How do we get it? The first phase—the determination of the various factors that are in existence—brings the *problem* itself clearly into focus. The second phase—the determination of a settled or definite course or principle of procedure or action for the problem at hand—establishes the *policy* that is to govern the solution. The third phase—which is that of setting up the procedure by which the policy may be carried out—leads to the *program* that will translate general ideas into specific plans. Thus the three phases of the planning process can be restated as follows: (1) Crystallizing the problem; (2) Determining the policy; and (3) Preparing the program. These three phases are interrelated and cannot properly be separated, but for the purpose of this discussion our attention will center on the second phase, i.e., the establishment of the policy that is to govern the solution.

Major Considerations

Although it represents an oversimplification, I shall begin my detailed discussion by stating that the determination of policy in the planning of Civil Engineering structures, when considered in its broad sense, includes the synthesis of six major considerations, and that these are the *social* (including political), *legal, functional, economic, technical,* and *esthetic* aspects of the problem.

Social aspects must be considered because the Civil Engineer deals with large projects, often of a public nature, that may have important effects on the lives of many people. These projects afford protection against man-made perils as well as the perils of nature. They affect the conservation of our natural resources. They affect housing and other living conditions. The opportunity to contribute to social improvement, and the sense of satisfaction and accomplishment that goes with this, are among the attractions of the Civil Engineering profession. But with this opportunity goes the responsibility of recognizing the social aspects of a problem, and giving them proper consideration in arriving at engineering decisions.

Legal aspects are almost always encountered. They may be in the form of codes specifying certain requirements that must be met in construction, or they may be zoning laws that regulate by districts the height, bulk, and use of buildings, the use of land, and the density of population. They may affect clearance requirements over navigable streams, or water rights in connection with a dam. In general, the legal aspects of a planning problem establish certain definite restrictions within the limits of which the planner must proceed.

Functional aspects are of utmost importance. Every structure is built to perform a certain function, and regardless of its other qualities, it must serve the purpose for which it is built if it is to prove satisfactory. The Civil Engineer does not primarily build a bridge or a tunnel, but rather a means for traffic movement across a body of water or a valley, or through a mountain. He does not primarily build an industrial building, office building, or apartment house, but rather places where people may work and live, protected from the elements, and in an environment that will permit their working and living to be effective and pleasant. He does not primarily build dams, aqueducts, water treatment plants and distribution systems, but rather he provides homes and

industries with water of sufficient quality and quantity. The bridges, skyscrapers, dams, etc., are but the instruments that are used to accomplish certain functions. It is the functions themselves that are the true objectives.

Economic aspects involve two major phases which are interrelated. The first consists of determining whether or not a project is economically justified. While annual cost can usually be established by methods that are largely rational, annual benefits may be more difficult to evaluate. While the latter may be of a tangible nature, they may be partly or wholly intangible. This is because it is often necessary to correlate economic and social benefits. Economic justification usually involves the second phase of the problem—namely, the search for an economically optimum solution. In dealing with this phase it is well to keep in mind that as a given parameter is varied so that the cost of certain items is reduced, the cost of other items will increase. This compensating tendency tends to prevent sharp changes in total cost as a parameter is varied, and this is particularly true in the region of the optimum. In general the objective should be that of assuring one's self that his solution lies near the optimum, i.e., it lies in what may be called the optimum range, rather than that of seeking truly optimum conditions.

Technical aspects are of first-order importance, but since they are amply covered in most Civil Engineering curricula, they will not be enlarged on here. Suffice to point out that while we may be prone to think of the technical requirements of a structure as being of a rather definite nature, there are actually many factors requiring judgment of a high order in connection with this aspect of planning. This is because technical requirements vary with social and technological changes, because they depend on the vagaries of nature, because they depend on operational uncertainties, and because they involve probability considerations. Nor is the technical performance of a structure as definite as we might wish. This results from uncertainties in properties of materials, in methods of analysis, in methods of fabrication and erection, and in connection with maintenance. The actual factor of safety that should be built into a structure will depend on considerations such as penalty for failure, expected life of structure, degree of certainty involved, etc.

Esthetic aspects include a consideration of fitness to function, materials, and techniques. They involve attention to unity, simplicity, good general lines, harmony with environment, and ornamentation. The engineer in designing a structure has the cards stacked in his favor to produce a beautiful structure, since by the very nature of his work he is seeking a design that is fitted to functions, materials, and techniques. Pleasing effects can therefore be obtained at little or no extra cost. In view of this, it is perhaps not too much to suggest that if beauty of structure is not achieved, it is likely to indicate poor engineering as well as lack of esthetic appreciation.

To recapitulate, the solution sought in a given instance is a complex function of many variables which must be synthesized by the planner by considering questions such as: Does it recognize social welfare and fulfill social needs? Does it satisfy legal requirements? Does it accomplish the function for which it is built? Is it economically justified, and does it represent the best possible expenditure of funds? Will it operate satisfactorily, and does it take advantage of recent advances in technology? Will it satisfy the desires of people, and bring them pleasure?

Examples of Application of Synthesis Methods

Let us now attempt to illustrate how the various aspects of planning may be combined in the search for a solution to a given problem. As a first example we shall consider an office building in a

metropolitan area, where one might proceed somewhat as follows: *Social* considerations would include taking into account the predominant activities of people in various areas of the city, and the trends in the shifting of these activities that could be anticipated, so that the building could be properly located. They would include a consideration of transportation problems such as accessibility to transportation terminals, street congestion, parking areas, etc. They would include a consideration of the factors covered by zoning laws, such as height and bulk of building, even though zoning laws might not exist. *Legal* considerations would include taking into account the building codes and zoning laws. The zoning laws, through height restrictions and set-back regulations, would be likely to exert a fundamental influence on the general shape of the building. *Functional* considerations would control floor layouts, indicating where light courts were necessary, and thus affect the shape of the building. *Economic* considerations would affect practically every step in the planning, and would be likely to determine the height of the building. *Technical* considerations would affect the details of the design and construction and might indeed have far-reaching effects on the shape of the building. For example, the foundation conditions might limit the weight and weight distribution of the structure. *Esthetic* considerations would affect the actual building shape chosen, together with the details of the exterior and interior treatments.

As a second example, we shall consider the planning of a highway bridge across a navigable stream: *Social* considerations would affect the over-all decision as to whether or not the bridge should be built, and the choice as to the general location of the bridge. The effect of the bridge on adjacent land values would also be taken into account. *Legal* considerations would include the decisions of the War Department with respect to underclearance requirements for navigation, together with factors such as land taking, land damage, etc. *Functional* considerations would determine the number and arrangement of traffic lanes as well as the arrangements for the entrance and exit of traffic. The hydraulic demand of the stream might affect underclearance and pier locations. *Economic* considerations might determine span lengths, would be likely to affect the type of superstructure, and would influence the general proportions as well as the details of the structure. *Technical* considerations would control the detailed design of the members and their connections. Through foundation conditions, they might determine span lengths as well as influence the type of both the substructure and superstructure. *Esthetic* considerations would be taken into account in choice of type and general layout of the structure, and would control any decorative efforts.

A Guide to Finding the Optimum Solution

One is now tempted to attempt to generalize by setting up a guide to the orderly approach of synthesizing the many factors involved in planning a Civil Engineering structure or project. While it must be clearly understood that the actual procedure that is desirable in a given case may vary widely from that of any standard approach, one might proceed somewhat as follows:

1. *View the over-all problem,* giving *preliminary* consideration to its social, legal, functional, economic, technical, and esthetic aspects. This preliminary "sizing up of the situation" will prevent one from going entirely astray as the more detailed parts of the problem are considered.

2. *Social considerations* should be an important factor in determining whether or not a project should go ahead, and in formulating, in a broad way, the general manner in which the problem should be solved.

3. *Legal considerations* usually lead to certain restrictions within the limitations of which the planning must proceed.

4. *Consider a number of possible solutions* that may satisfy *functional* requirements and that are within the realm of reason from the *economic* viewpoint.

5. *Make preliminary designs* for the various reasonable solutions, giving full consideration to the *technical* aspects of the problem.

6. On the basis of these preliminary designs, *select the most satisfactory solution,* with the decision guided by *economic, functional* and *esthetic* considerations.

While the above outline suggests an orderly approach that can sometimes be followed to advantage, it should be emphasized that the reduction of the problem to a step by step procedure does not reduce it to one of analysis only. The correct procedure is one that involves synthesis as well as analysis in thinking. The actual process will involve scanning and rescanning the entire project with respect to all of its aspects; this more or less informal process will and must be superimposed on any rational approach.

Further, it is to be emphasized that while general considerations may be likely to reduce the number of solutions that merit further study—this coming about largely through the process of elimination for schemes with more or less obvious defects—*the final choice, in most cases, can only be made on the basis of comparative studies.*

What we are seeking in a given case is, of course, the most satisfactory solution, which, for the sake of brevity, we shall call the optimum solution. It is perhaps axiomatic that for any proposed Civil Engineering project there is one type of solution that is better suited to existing and future conditions than any other type. The optimum solution results from a consideration of *all* the variables in a problem, and will usually represent a compromise between the objectives of the individual variables. Moreover, the relative importance of the individual variables differs with each project. But it is seldom if ever that the broad gage engineer can or will completely ignore any of the basic elements. He must approach his problem from the *over-all point of view.*

Having accepted the concept of the optimum solution, a number of comments are in order. A so-called truly optimum solution usually has little meaning. Even if a theoretical optimum could be computed, such computations are based on assumptions that invalidate strict interpretation. Actually there are too many variables in most planning problems to permit the hope of working out a theoretical optimum. But these observations need not be discouraging. As was pointed out in discussing economic considerations, when one investigates the effect of changing one variable in a problem, he usually finds that the effect on the total is not too pronounced because of compensating factors. Stated another way, most over-all functions are continuous. Optimum points are not unique. The optimum range is of more importance than the theoretical optimum point. The optimum solution constitutes a general objective even though it is never reached. The fact that it cannot be reached should not prevent one from devising the best solution that can spring from his abilities.

And in devising the best over-all solutions of which he is capable, the student in Civil Engineering will be laboring in a climate that stimulates synthesis as well as analysis in thinking. He will gain experience in the integration of many factors in reaching decisions. And perhaps it is not too much to hope that as he gages his thinking to the broad scales of reference that typify the planning process, he will be aided in developing his potential capacities to achieve a sense of balance and to render sound judgments.

We have all heard about the small boy who took the family clock apart to find out what made it tick. I salute him for his intellectual curiosity, but I would like to help him put the clock back together again.

* * * * * *

DISCUSSION BY W. L. HYLAND, PARTNER

Fay, Spofford and Thorndike, Boston, Massachusetts

Dr. Wilbur's characterization of the planning process as one of synthesis rather than one of analysis is a fresh and stimulating approach to the subject of planning. As one who directs the work of a number of engineers, I should like to make some practical comments on Dr. Wilbur's paper. First, I will discuss the part played by the engineer in the planning process; then, the aptitude of engineers for this phase of engineering, and finally I will make a few suggestions as to the training which the young engineer needs to improve his aptitude for planning.

Dr. Wilbur has referred to the three phases of planning, namely, (1) crystallizing the problem, (2) determining the policy, and (3) preparing the program. The first two phases cover what is commonly termed the preliminary planning stage and the third phase is the detailed design. My comments will relate to the preliminary planning stage.

We all know that the preliminary planning of an engineering structure is not the work of the engineer alone, but that it usually represents the work of many individuals and groups. This is particularly true of public projects. Consider for instance, a large municipal sanitary project—the preliminary layout finally adopted for such a project will reflect the views of local officials and groups as well as those of the engineer, and must have the approval of the State Department of Public Health. Consider a federal aid airport project—the preliminary plan must receive the approval of the Civil Aeronautics Administration as well as that of the Local Airport Commission and should be acceptable to groups of local citizens, such as the Chamber of Commerce. If it is a Massachusetts project, approval will be required also of the Massachusetts Aeronautics Commission and the Massachusetts Public Buildings Commission. Consider a project being handled by a private engineer for the Department of the Army. Here the preliminary plans may be reviewed by the Chief of Engineers, the Division Engineer, and the District Engineer having supervision over the work, also by the Using Agency. Projects for private owners usually do not receive the attention of as many different groups as public projects; nevertheless the ideas of many people are presented for consideration in the preliminary planning stage.

Now the engineer has to sift and to coordinate the ideas of these various groups and to satisfy them as to the plans finally adopted. Although the preliminary plan is usually the engineer's responsibility, sometimes laymen play a larger part than the engineer; this is so particularly for projects with preeminent social and economic aspects, these being the categories in which the layman can make his greatest contribution. When there is considerable layman participation, the planning process is time-consuming and a large project may take years. A case in point is the sewerage system for the City of Cranston, Rhode Island, which remained in the planning stage in the writer's office for almost twenty years before authorization was given for the detailed design. During this period the project was rehashed many times before all parties were satisfied.

Obviously, in initiating the plan and in synthesizing the ideas of others incorporated in it, the engineer has an opportunity to render professional service of the highest type.

In terms of cost, the planning stage usually represents from 15 to 25 per cent of the combined cost of planning and designing a project. However, the engineer plans more projects than he designs and, in the aggregate, the individual professional engineer spends about as much time on preliminary work as on final designs. Engineers high in their profession spend more time in administrative and planning functions than in final design. Planning is such an important function of civil engineers who have passed from the sub-professional to the professional stages of their careers that preparatory training in planning appears to be in order, as follows: (*a*) Undergraduate instruction in planning and (*b*) Self-instruction and conditioning by young engineers along lines mentioned later.

Now, we might ask what aptitude does the average engineer display for over-all planning. It is the writer's experience in observing the work of young engineers over a period of many years that they have little conception of the planning process, or of its aspects. Of course, even if they had they would need experience to become effective planners just as they would need experience to become effective designers. But it appears that their training has been such that they are much better adapted to designing than to planning.

In my opinion some of the reasons for this lack of planning aptitude are as follows:

(*a*) They have not been exposed to instruction in planning;

(*b*) They are in a technical rut. Since leaving engineering school their work has been confined to the technical aspects of final design and construction. They have neglected to cultivate civic and cultural interests and have not been conditioned to recognize opportunities to rise to a higher professional level.

A great handicap to the young engineer is his apparent neglect to improve his use of the English language. He appears not to recognize the necessity for excellence in the preparation of written reports and for making data presentable and easily digestible.

I suggest that the students be exposed to the kind of thinking given in Dr. Wilbur's paper. Also that they be encouraged in preparing final theses to attack problems having aspects other than the merely technical. By all means more stress should be laid on courses in English. Furthermore, they should be advised to broaden their scope by attending meetings, not only of professional societies but of civic groups, where they will mingle and work with people other than engineers.

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DISCUSSION BY ROBERT B. B. MOORMAN

Professor of Civil Engineering, University of Missouri

Again Professor Wilbur has presented a thought provoking paper. We civil engineers are too prone to think only of the technical aspects in the planning of projects. However, Professor Wilbur has opened the gate to greener pastures upon which we may graze.

I would like to recapitulate the six major considerations presented by Professor Wilbur in the light of my experience in connection with the planning of an expressway for the City of Richmond, Virginia. It should be understood that I am not attempting to give a complete picture of the items under each of the six major considerations, but merely to point out that there are items to take into account under each of the six major con-

siderations. Also, I shall add two or three more subjects to think about.

The *social* aspects, which I consider to be extremely important, enter the picture through the possibility of slum clearance, confinement of the central business district, and making possible the opening of new subdivisions.

The *legal* aspects would include the determination of how far the engineer can go in the condemnation of property and buildings, in the disruption of the business of concerns on the route, and of zoning considerations, i.e., the use of the expressway where possible, to separate the business or industrial zones from the residential zones.

The *functional* aspects are: to provide for uninterrupted flow of traffic through congested districts, and to provide easy access to the central business district from outlying districts.

The *economic* aspects to consider are the most economical layout from a purely technical standpoint, razing of least expensive buildings, savings to user in regard to gasoline, time, wear on car, etc., and enhancement of property values adjacent to expressway.

The *technical* aspects to consider are use of latest technical information in regard to drainage, road surface, lighting, marking, sight distance, structures, etc.

The *esthetic* aspects consist of such things as landscaping and providing graceful grade separation structures.

To these six major considerations I would add the following items. We might possibly consider them as submajor.

Financing aspects might in some cases be classed under the economic heading. What I have in mind is the raising of the necessary capital to finance the project. There may be a private investor or a public investor. The public investor (city, state, or, federal government) would raise the necessary funds by taxation. There would more than likely be a bond issue election. This brings up another consideration.

Selling the idea aspect is a necessary evil. We engineers ordinarily do not think of ourselves as salesmen. Yet every project must be sold in some way or another. The idea of the project must be presented to the interested and influential groups in such manner that they will back it. In this respect we must maintain good public relations; and an excellent method of doing this is to cooperate with the newspapers and get them on our side.

Another aspect which seems important to me is *National Defense.* Along this line I would say we must guard against easy sabotage of any project with which we are concerned.

Returning to the original six major considerations, we may compare them to six steps in the construction of a sentence. (1) The technical aspect is the alphabet whereby we have a means for construction. (2) The esthetic aspect is the word whereby we make pleasing sounds. (3) The legal aspect is the grammar or set of rules whereby we arrange the words. (4) The economic aspect would consist of using only the necessary words to make our point. (5) The functional aspect is the construction of the sentence. (6) The social aspect is the most important of all for it is the meaning of the sentence.

Meeting

A meeting of the Cooperative Engineering Division of the A.S.E.E. will be held at the University of Detroit on January 24 and 25, 1950. For additional information contact D. C. Hunt, University of Detroit, Detroit, Mich., or H. L. Minkler, Illinois Institute of Technology, Chicago, Ill.

Research Policies and Pitfalls[1]

Summary Prepared by JOHN I. MATTILL,
Secretary, Engineering College Research Council

Assistant Director, News Service, Massachusetts Institute of Technology

Policies and pitfalls in the administration of university research (termed by Ralph E. Montonna "a delicate flower which must not be forced") were the subject of eight university research directors at a roundtable of the Engineering College Research Council of the A.S.E.E. in Kansas City, October 28. "Academic research," said Dr. Montonna, Director of the Industrial Research Institute at Syracuse University, "if properly stimulated can become a very beneficial part of university activity."

Since colleges have no desire to let research overshadow educational goals, Charles W. Williams, Coordinator of Research at Case Institute of Technology, pointed out, college administrators must "examine research in a different light than if it were a goal to be pursued in itself." The effect of research on other university activities should be considered, he stressed.

All participants agreed in emphasizing integration of research with educational effort; the character of research should be such that all projects fit in "with the research interests and desires of the faculty," Dr. Montonna said. All administrators reported efforts to encourage their faculty members to participate in research. Where an engineering experiment station is only beginning to function, as at the University of Arkansas, this presents special difficulties, Dean George F. Branigan reported. J. O. Maloney, Executive Director of the University of Kansas Research Foundation, said that some faculty members may hesitate to accept projects under industrial sponsorship because these are regarded as "risk" operations in which a failure to produce results within a specified time limit may endanger professional reputation.

"It has been our policy," declared Clark A. Dunn of Oklahoma A. & M. College,[2] "to encourage research workers to begin with simple problems, out of which almost always come questions of a more important and fundamental nature." At Oklahoma A. & M., as elsewhere, special efforts are made to recognize research work and to publicize it as rapidly as possible, "giving full credit to the research worker for his contribution."

Extra compensation for faculty members participating in sponsored research was reported by some roundtable participants, notably Dean R. C. Ernst, Director of the University of Louisville Institute of Industrial Research. Other speakers reported that research was encouraged only to the extent of reduced teaching loads wherever possible; such a policy is

[1] A summary of the papers and discussion at a roundtable on "Research Policies and Pitfalls: Policies to be Adopted and Pitfalls to be Avoided in Developing a Research Program Serving Teachers, Students, Industry, and the State," presented before the Engineering College Research Council in Kansas City, Missouri, on October 28, 1949. Texts of the brief papers presented at the roundtable are available from the Secretary of the Research Council.

[2] The paper prepared by Dr. Dunn was read by Dean Edward R. Stapley.

designed to keep faculty emphasis on educational goals. Most participants reported permitting students to be employed on research, though some do not pay students working on thesis projects.

J. Hugh Hamilton, Director of the Utah Engineering Experiment Station, University of Utah, stressed the importance of assured continuity in academic research activities. Thus there is hesitation to accept short term industrial and government contracts, especially in small schools where one contract may provide a significant portion of research income.

Proper administration of patents was also cited as important in stimulating research activity. The main function of university-held patents, said Quincy Ayres, Assistant to the President at Iowa State College, is not to make money but to stimulate interest in and protect university research results. No "infallible rule for predicting in advance the income-producing proclivity of any patent" seems to be known, he said.

Library searches, which are necessary to establish the foundation and value of any contemplated research project, are often a difficult and tedious process for faculty and graduate students. Dr. Dunn reported that a member of the Oklahoma A. & M. engineering library staff has been especially selected to help researchers in this task. While most engineering schools have excellent teaching libraries, essential research data may be missing, Dean Branigan said. Funds from sponsored research overhead may be allocated for this purpose; at many educational institutions such funds are used to support studies by faculty members for whom direct industrial contracts are not available.

Such a policy helps to make possible a relatively even distribution of research in all departments, cited by Dr. Williams as one of the administrative goals at Case Institute of Technology. Inter-departmental cooperation was seen as one major benefit to be derived from any comprehensive research project.

At Oklahoma A. & M. College, a Research Apparatus Development Laboratory serves all research workers by "providing a knowledge of the available equipment and methods of designing equipment to meet specific needs." Many research workers, Dr. Dunn declared, "know only what they wish their equipment to accomplish" and so require the services of such a special design group.

The benefits to be derived by faculty members participating in research projects were graphically suggested by Dean Ernst, who reported on the results of A.S.E.E. grants made possible by the General Education Board in the Southeastern Section. In cooperation with the Tennessee Valley Authority, faculty members have undertaken specific research problems and report "practical and realistic training" which eliminates the "inbreeding and narrowness found on some college campuses."

Without exception, research directors participating in the Kansas City round-table reported faith that their organizations, properly managed, can stimulate faculty and student research and publication and can provide improved facilities and environment for educational activities. Some believed that research, either directly or indirectly, could contribute to increasing staff stipends. All agreed with Dr. Montonna that "sponsored research is a proper university activity if kept within proper bounds. Research should not be set up in a university as a money-making activity."

Bridging the Gap*

By G. P. BOOMSLITER

Professor of Mechanics, West Virginia University

The complaint has often been made that teachers in engineering, indeed I might even say teachers in all academic subjects, tend to confine their teaching to compartments, little related to other subjects in the curriculum, and I presume that most of us will agree that this is true if our particular courses are excepted from the general rule.

Civil and Mechanical engineering instructors assert that Mechanics falls short of transferring to their students what they need. Mechanics deplores the fact that students come to them inadequately prepared in physics and mathematics and they in turn blame the high schools.

Many years ago Miss Sada Harbarger, whom many here remember as an active member of this society, and who was Vice-President in 1936–37 wrote a paper entitled, "The Sag of the Second Year" which was published in the proceedings of the society. She viewed with concern the drop in grades of the engineering class from the freshman to the sophomore year, but noted their recovery in the two succeeding years. She ascribed it to the fact that there was not enough of engineering in the courses of this year to hold the interest and enthusiasm of the student after the novelty and excitement of the first year had worn thin. She felt that the service courses taught during this second year did not adequately bridge the gap.

Interest Arousing Service Courses

Therefore, I am presuming that what I am to talk on is, how the teaching of any service course, while grounding the student in the fundamentals of that subject, can show how it fits into other subjects of the curriculum so as to develop in the student a desire to pursue the subject further in its application to other science, and to prepare the subgrade, as it were, for the foundations in the subjects which follow. To illustrate, the teaching of the moment of inertia of areas and of masses affords excellent examples for drill in integration. In addition, a brief discussion of the origin of these integrals and of their application to mechanics and engineering would stimulate the student to a fuller appreciation of the calculus and make their use later more understandable.

Similarly, physics teaching can point out many applications of fundamental principles to interesting physical phenomena in mechanics, electricity, sound and light that would serve the two purposes of giving interest not only to that subject, but of developing interest and curiosity in the engineering situations where these phenomena are used.

It is not my intention in this talk to condemn, or apologize and explain, but merely to suggest how mechanics, considered as one of the many service courses which we have in engineering, can be so taught as to serve the various departments of the engineering college and also participate fully in turning out a satisfactory product in the engineering graduate.

Once when I was working as an undergraduate for the college carpenter at Michigan State College, I tried to finish a piece with a pocket knife instead of using a wood plane. He caught me at it

* Presented at the Allegheny Section Meeting of the ASEE, University of Pittsburgh, April 22, 1949.

and after a few well-chosen remarks, he said, "You can noddings do unless you have sometings to do mit!"

Now what do we need and what is available to make the teaching of mechanics a satisfactory service to the other departments? What do we have to "do mit"? First, of course, is the raw material—the students. These, generally, have been screened before coming to Junior mechanics and the better the screening, the better the material. I will not dwell on this, except to say that with the same scholastic training, the more mature students with some experience tend to be the best material to work on. Next is the instructor. Let us suppose that he has been selected with care. He is properly trained academically, which means that he has one or more degrees in engineering and is mentally alert, enthusiastic and sympathetic. What else does he need? Well, a year or two of engineering experience is very valuable. Failing this, summers spent in industry are desirable. This is desirable even if he has had some previous engineering experience. It is also desirable that the instructors in the department come from the various branches of engineering: civil, electrical, mechanical, aeronautical, etc., so that the needs of all departments are most effectively met through the combined knowledge of all in the department.

Then there should be a departmental library in which will be found the best text books in the field of mechanics, both those which are currently popular and those which are out-of-date; the first to develop other points of view—the second to show how present methods of presentation have developed. Also of much value will be the text books in the courses for which mechanics is prerequisite, texts in machine design and simple structures, for example. It should also contain current magazines in the various fields of engineering, or the instructor should subscribe to the ones in his field. Many problems which can be adapted to the class room are obtainable from them.

Instructional Aids

Mechanics principles can be made clear and interesting by the use of simple devices. A few helical springs of various lengths, a rubber beam, flexible steel bars and slender rods to demonstrate the action of long columns and beam deflections. A pendulum or two, revolving tables and gyroscopes to demonstrate dynamic principles, etc. We have a cylindrical box in which is mounted a wheel from a model T Ford with a strip of lead in the rim to increase the moment of inertia. It can be rolled along the floor, but to turn it, a tipping motion is necessary and conversely, deliberately trying to turn it results in its tipping over. A few minutes with this boxed wheel gives a student an excellent illustration of gyroscopic action.

How many instructors have longed for a collection of simple machines such as delight the small boy who visits the Franklin Institute in Philadelphia.

Several years ago Professor Roark of Wisconsin gave a paper before the Mechanics section of the society on "Mechanics in Every Day Experience" in which he cites Prof. Osgood as saying, "The world in which we live is the true laboratory of elementary Mechanics." In this world of the student and teacher are the college shops with their machines, engines, motors and hand tools. On the campus or nearby, new buildings are under construction which, besides showing the application of the laws of mechanics in their construction, are of interest because of the tools employed in their building, shovels, trenching machines, hoisting equipment, floor and wall forms for concrete, etc. The great plants in a great city like Pittsburgh, thanks to courteous and accommodating managers, can be of great service to engineering educators.

Also in the world of all of us, we have base balls, golf balls, automobiles, roadway curves, slippery pavements and the dynamic effect of the failure of the coefficient of friction to maintain equi-

librium. By making use of such devices in mechanics, we can serve the various departments in several ways.

In general we can first develop the student's interest in mechanics and, second, show him its important application to his chosen field of engineering. An enthusiastic student needs no prodding and the secret of good teaching is to make him enthusiastic. Few of us have learned this secret, at least as it applies to a group.

For stimulating the civil engineer, simple structures under construction offer many opportunities. Trusses may be analyzed, floor loads checked, safe column loads determined, walls and footings observed. In a similar manner, modern machine motions may be studied and compared with the older ones used in the shops, stress distribution analyzed, governor action observed. These are all connected with mechanical engineering. In aeronautical engineering, illustrations of aeroplanes will generate discussions on how to eliminate weight and still obtain adequate strength. Samples of thick high pressure pipe in service will show the chemical engineer that there is more to a course in strength of materials than just obtaining a passing grade. Torques in motors can be determined for installations about the campus and the many analogies between Mechanics and Electrical theory should be a stimulus to electrical students.

The illustrations just given for Mechanics will serve also as a stimulus and a bridge in teaching in the Materials Testing Laboratory, but here the bridge should be obvious, or if the course is given concurrently with the course in Strength of Materials, the bridges will be built there. This course should familiarize the student with the common types of testing machines, and with methods of testing, increase his facility for reading data from graphs through making his own and give him a nodding acquaintance, at least, with ASTM standard specifications, but that should not be the principal object of such a course. The first aim should be to translate definitions of such terms as Modulus of Elasticity, Proportional Limit, Ultimate Strength, etc., into well grounded concepts. No one can deal effectively with words which he does not understand.

These are some of the devices for bridging the gap between Mechanics and the professional courses. There are gaps between these courses and the prerequisite courses in Mathematics and Physics that must also be bridged. Physics, for instance, is a broad course of which mechanics is one division, electricity another. What is the gap to be bridged here? I have heard instructors in Electrical Engineering express the wish that students come to them grounded thoroughly in the basic principles of electricity with less stress on what they consider the frills not essential to Electrical Engineering. Mechanics instructors also would be happier if a thorough knowledge of elementary principles were transferred to them.

Need for Hybrid Instructors

One of the best methods of achieving the latter result is an exchange of instructors between the two departments who could then bring back to their department the requirements, problems and points of view of the other one. Another is to have both these groups as well as instructors in the various branches of engineering participate in an Engineering Problems course given in the Freshman year. Picked instructors from Mathematics could well be added to this group. Mathematics has many of the same opportunities to excite an interest in mechanics and engineering, as have been already discussed with regard to Mechanics and the Engineering courses. If Mathematics instructors could acquire the practical point of view of Mechanics, and Mechanics instructors an appreciation of the value of rigid analysis, which is found in Mathematics, both would work most effectively in developing enthusiasm for and understanding of the

various fields of engineering that are so essential to effective training.

But acquiring the facts of a course and even a knowledge of where they are applied in engineering is not the main goal in teaching analytical mechanics. More important is drill in methods of analysis, the direct application of the scientific method without which the graduate engineer is gravely handicapped.

All of the terminology and fundamental principles of any course in mechanics can be written on one sheet of foolscap paper and could be memorized in a week. A knowledge of their application to engineering could be obtained in another week. The rest of the semester is used not in showing the student how they are applied, but in training him in the best methods of doing this himself, in developing his analytical ability.

Professional Objectives

In the November number of the JOURNAL OF ENGINEERING EDUCATION, under the title, "Education for Professional Responsibility," Dean Hammond, as editor, reports on an Interprofessional conference held at Buck Hill Falls, Pa., last April. He used the notes taken by Professors Teare and Smith of the Carnegie Institute of Technology.

He reported that there was a remarkable agreement among all professional groups as to the chief objective of professional education. I quote his statement of this objective, . . . "The chief objective of professional education is the development of the power to acquire and use knowledge as contrasted with the mere process of acquiring knowledge which the student has not used or tested for himself. . . . For an engineer, use of subject matter and skills should be primarily in solving problems. . . . The power to get answers and to put them to work in dealing with actual situations can be developed."

He quotes Professor Teare as dividing cases into *instances* from which general principles are deduced, and *problems* which are used to learn how to use the principles which have been clarified by the solution of *instances*.

Now Mechanics is eminently adapted to do both of these things; first, *instances* to fix principles, and second, *problems* to apply them. Design the joists for the new home or the concrete floor for the new porch, or the shaft for a motor installation, or a spring to carry a given load with a desired coefficient. Check the design on equipment used about the campus or in the shops.

The speaker on one occasion had an amusing experience with a class in Strength of Materials. After discussing the theory of helical springs and noting that there were three variables with but two conditions for their solution so that one had to be assumed before the others could be found, he offered a prize of a lollypop to the student who designed the most economical spring; i.e., the lightest one. When the problems came in, he found that half the class had springs which though of various sizes had the same weight; and taxed the resources of the local candy store to furnish enough lollypops to satisfy the successful designers. It was also of interest that some students tried a dozen different combinations in the effort to obtain the most economical spring. Further investigation of the formula showed that for a given set of working stresses, the weight turned out to be a constant.

The case system in law is used effectively to attain the objectives cited by Professor Teare; i.e., first to deduce the underlying principles of law and second to apply them to new situations. The solution of problems is the use of the case system in engineering.

Requisites of the Teacher

Much emphasis has been placed here on how to bridge the gap in instruction in Mechanics. Instructors in other service courses will find similar means to attain these same objectives relative to

other courses for which theirs are prerequisite.

However wideawake an instructor may be, he must have time to think and plan in connection with his work. With the present large enrollments, there is a tendency to make classes too large and the number of teaching hours too many, and this results in the defeat of many good plans for effective teaching. Seeing a young teacher of English going home with a great armful of papers, her superintendent said, "Remember Miss Blank, a rested teacher is worth any number of graded papers."

I have already stated that an enthusiastic student needs no prodding, but it takes an enthusiastic teacher to develop an enthusiastic student, and enthusiasm depends to some extent on physical energy and mental freshness. The teacher must have time for current reading, intercourse with his colleagues, for attending meetings and experimenting with or making gadgets to illustrate current classroom principles. Too many classes of too many students or a burden of detail or clerical work tends to defeat the best laid plans for effective teaching.

The current issue of *Civil Engineering* quotes Dean Finch of Columbia University's School of Engineering as saying that enrollment there must be reduced from a war-time high of 1100 and a present enrollment of 948 to 800 if the school is to make its best contribution to engineering education and American life. He continues by saying that the facilities of the school have been "taxed to the utmost" in response to a national emergency. Instructors so taxed will have little time to plan how to bridge the gap.

Mid-Year Meeting of Engineering Drawing Division

The meeting will be held January 19, 20 and 21, 1950, headquarters at the University of Illinois, Navy Pier, Chicago. Registration will start on Wednesday, January 18. Northwestern Technological Institute and Illinois Institute of Technology will act as co-hosts with the Chicago Undergraduate Division of the University of Illinois in making all arrangements for the conference.

The conference will open Thursday, January 19th with an inspection trip through Carnegie-Illinois Steel Co., leaving Navy Pier by bus at 9:00 A.M. This will be followed by a visit to the Illinois Institute of Technology in the afternoon. A meeting of the Executive Committee of the Drawing Division will be held Thursday evening.

Friday morning at 9:30 the group will leave Navy Pier to visit the Eugene Dietzgen Company and will be guests of the Dietzgen Company for lunch. In the afternoon the group will visit the Northwestern Technological Institute followed by a conference with speakers from schools and industry. The Annual Mid-Year dinner will be held at University of Illinois, Navy Pier at 7:00 P.M.

Saturday morning the second conference will open at the University of Illinois, Navy Pier at 10:00 A.M. Talks by a man from industry and two from the schools will be given. The meetings will be concluded by a luncheon served in the faculty dining room at the University of Illinois, Navy Pier.

Transportation for both of the industrial trips will be furnished by the host schools. This should be a very worthwhile and interesting conference and we urge all members of the Drawing Division and their friends in the A.S.E.E. to attend.

A Note on the Method of Iteration

By JOHN E. BROCK

Washington University, St. Louis, Mo.

The purpose of this brief note is to direct attention to the fact that the so-called method of iteration[1,2] for solving ordinary algebraic or transcendental equations is at its very best, equivalent to the Newton-Raphson method, and even then involves essentially a greater amount of calculation. Thus, there is no reason ever to use or teach the method of iteration.

In the method of iteration we take the equation,

$$f(x) = 0$$

and write it in the form

$$x = g(x).$$

(This may usually be done in more than one way.) Suppose x_0 is an approximation to the desired root. We form successively the approximations,

$$x_1 = g(x_0),$$
$$x_2 = g(x_1), \quad \text{etc.}$$

This sequence converges to the desired root if $|g'(x)| < 1$ in the neighborhood of the desired root.[3] The convergence is most rapid if $g'(x) \cong 0$ in the neighborhood of the root. If we write,

$$x = (1 - \alpha)x + \alpha x$$
$$= (1 - \alpha)x + \alpha g(x) = h(x),$$

by choosing $\alpha = \dfrac{1}{1 - g'(x)}$ we have,

$$h'(x_0) = (1 - \alpha) + \alpha g'(x_0) = 0,$$

so that the iterative method will converge *most rapidly* for the function

$$x = h(x).$$

Then

$$x_1 = h(x_0)$$

is the first improved approximation. Noting that

$$x = g(x) = f(x) + x$$

(in whatever manner $g(x)$ is obtained), we have

$$x_1 = \left[1 - \frac{1}{1 - g'(x_0)}\right] x_0 + \frac{g(x_0)}{1 - g'(x_0)}$$
$$= x_0 - \frac{g(x_0) - x_0}{g'(x_0) - 1} = x_0 - \frac{f(x_0)}{f'(x_0)},$$

which is exactly the approximation given by the Newton-Raphson method. It is clear that the calculations involved in the Newton-Raphson procedure are essentially fewer in number.

Continuing the iterative process without recalculating an improved value of α is equivalent to continuing the Newton-Raphson method without recalculating the improved value of the derivative, for by the iterative method we have,

$$x_2 = h(x_1)$$
$$= \left[1 - \frac{1}{1 - g'(x_0)}\right] x_1 + \frac{g(x_1)}{1 - g'(x_0)}$$
$$= x_1 - \frac{g(x_1) - x_1}{g'(x_0) - 1} = x_1 - \frac{f(x_1)}{f'(x_0)},$$

while calculating an improved value of α, $\alpha = \dfrac{1}{1 - g'(x_1)}$, is equivalent to repeating the Newton-Raphson procedure

[1] J. B. Scarborough, "Numerical Mathematical Analysis", The Johns Hopkins Press, Baltimore, 1930, p. 184.

[2] E. T. Whittaker and G. Robinson, "The Calculus of Observations", Blackie and Son, Ltd., London, 1924, p. 79–84.

[3] Scarborough, *op. cit.*, p. 186.

with a new value of the derivative, *i.e.*,

$$x_2 = x_1 - \frac{f(x_1)}{f'(x_1)}.$$

The only time the iterative method might conceivably enjoy an advantage is in the case where we write

$$x = g(x)$$

and it *happens* that $g'(x_0)$ is small, *and* the first or second approximation is sufficiently accurate for the purpose at hand, *and* the calculations are very easily performed. In such a case it would not ever be necessary to calculate $g'(x_0)$. However, in the absence of the knowledge that $|g'(x_0)|$ is small one would be foolish simply to go ahead hoping for the best, and to obtain this knowledge involves calculating $g'(x_0)$.

Incidentally, with respect to the Newton-Raphson Method, it may be pointed out that it is frequently of advantage in computing the first correction to retain second order terms, *i.e.*, to use

$$f(x_0) + \delta x f'(x_0) + \tfrac{1}{2}\overline{\delta x}^2 f''(x_0) = 0,$$

rather than simply

$$f(x_0) + \delta x f'(x_0) = 0,$$

in obtaining δx (where $x_1 = x_0 + \delta x$). In the first stage of the process when the number of digits in the approximate root is small, solution of the quadratic may give a sufficiently better value for δx (as compared to the linear approximation, $\delta x = -\dfrac{f(x_0)}{f'(x_0)}$) to warrant the additional labor. This is not generally true in later stages of the process.

In the News

Federal Security Administrator Oscar R. Ewing announced the creation of a new division in the Bureau of States Services, Public Health Service, to be known as the Division of Engineering Resources. At the same time, Mr. Ewing made public the appointment of M. Allen Pond, Assistant Chief Sanitary Engineer of the Public Health Service, as chief of the new division. Surgeon General Leonard A. Scheele said the Division of Engineering Resources will centralize planning and development of current and proposed programs of the Public Health Service in the expanding field of sanitary engineering and environmental health.

"These are some of the things that, I believe, industry expects from the engineer —achievement, orderly thinking, vision, and the ability to apply these great gifts to human, as well as technical, problems. If I could be permitted to make one suggestion to that engineer as he faces a career in American industry, it would be this: don't be content to deliver just what is expected. Give industry more than it expects. You will then be rewarded by being given even more responsibility and more problems, but these are the dynamics of true progress."—Remarks in address of Charles E. Wilson, President of General Electric Company, at 125th Anniversary of Rensselaer Polytechnic Institute, Troy, N. Y., October 14, 1949.

Division Forum

Student-Faculty Evaluation Subcommittee of Division of Educational Methods

This committee was established by the Educational Methods Division in April, 1949. Its purpose is to review the various programs used by students to evaluate the effectiveness of staff members as teachers. The committee will solicit factual information and opinions regarding these programs from the persons who have been associated with them.

It is not the purpose of the committee to promote evaluation systems and it has not begun its work with the premise that they are desirable. It is thought that comprehensive information on the subject would be useful to all schools in deciding (1) whether or not an evaluation program is desirable and (2) what kind of a program would be most desirable. In the preliminary work of the committee there has been discovered strong sentiments both for and against faculty evaluation programs of all kinds. This certainly betrays considerable thought and discussion on the subject.

The committee plans to sponsor a program at the national convention in Seattle next June. This program will encompass the entire field of faculty evaluation. In addition to a report on Student-Faculty Evaluation there will be one on Administrator-Faculty Evaluation. Other phases of the program are currently being developed.

The members of the committee are Harry W. Case, University of California; John W. Cell, North Carolina State College; Edwin H. Gaylord, Ohio University; Pierre Honnell, Washington University; George G. Lamb, Northwestern University; W. B. Shepperd, Pennsylvania State College; and Paul K. Hudson, University of Illinois, Chairman.

P. K. HUDSON, *Chairman of Subcommittee on Student-Faculty Evaluation*
ERIC WALKER, *Chairman of Educational Methods Division*

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

Seattle, Wash. **June 19–23, 1950**

Organization of the Pan American Union of Engineering Societies (UPADI) and the First Pan American Engineering Congress

By S. S. STEINBERG

Chairman, United States Delegation

Dean of Engineering, University of Maryland

The preliminary meetings for the organization of the Pan American Union of Engineering Societies (UPADI) was held in Sao Paulo, Brazil, from July 9 to July 14, 1949, immediately following the Sixth Convention of USAI (The Union of South American Engineering Societies) which was held on July 9. That evening, the formal closing of the USAI Convention and the opening of the UPADI meetings took place at the Municipal Theatre in Sao Paulo at which each chief of delegation made an address. The presiding officer was Dr. Clovis Pestana, Minister of Railroads and Public Works, who represented the President of Brazil.

The presiding officer of the meetings for the organization of UPADI was Engineer Alvaro de Souza Lima, President of the Engineering Institute of Sao Paulo. A Committee was appointed from the delegates of each of the countries represented to consider the proposals previously prepared for a Constitution for UPADI.

The formal opening of the First Pan American Engineering Congress took place on the evening of July 15 at the Municipal Theatre in Rio de Janeiro at which several chiefs of delegations were asked to deliver addresses. The scheduled sessions of the Congress and its Commissions commenced the next day. At a meeting of the official delegates of all the countries represented, the Constitution for UPADI was unanimously adopted. Of the 22 countries in the Western Hemisphere invited to the UPADI meetings and to the Congress, the following 17 sent delegates: Argentina, Brazil, Canada, Chile, Colombia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Paraguay, Peru, United States, Uruguay and Venezuela. It was decided that when the national engineering societies of 15 nations have accepted the UPADI Constitution, the organization would be considered formed, and that thereafter an organization meeting would be held in Havana, Cuba, provided that country had accepted membership in the organization.

Throughout the discussions for the founding of UPADI, the United States delegation acted as observers and were available to advise and to express opinions regarding the probable attitude of the engineering profession in the United States with reference to each of the provisions of the proposed Constitution. The delegate from Canada and those from Venezuela acted also as observers. It appeared that the national engineering society of Venezuela is prohibited by present law from joining any outside organization such as UPADI; consequently, that country is the only one in South America not a member of USAI. Before the close of the Congress, it became apparent that the Venezuelan delegates would recommend that the engineers of

their country join UPADI if the legal prohibition can be removed.

The hope was expressed by all the assembled delegates that the United States engineers would find the Constitution of UPADI acceptable and that they would join that organization at an early date.

It is estimated that the potential membership of UPADI from its possible constituent organizations is 108,000 professional engineers, consisting of about 12,000 now in USAI, 90,000 represented by Engineers Joint Council, and 6000 in the other countries of the hemisphere, including Canada. The first Pan American Engineering Congress, officially authorized and sponsored by the Government of Brazil, was attended by 800 engineers, officials, and guests, representing nearly all the countries of the Western Hemisphere.

The program of the Congress was unusually comprehensive in scope and dealt with all the major branches of Engineering. The presiding officer was Engineer F. Saturnino de Brito Filho who did an excellent job in what were, at times, difficult situations. The official languages of the Congress were English, French, Portuguese, and Spanish. Translations were made at meetings as needed and requested by the delegates. It is interesting to note that of the 350 papers presented, more than a third were in English, somewhat less than a third in Portuguese, a smaller number in Spanish and only a few in French.

Each paper presented to the Congress was referred to one of nine Commissions dealing with the various branches of Engineering into which the Agenda were divided. These Commissions were as follows: (1) Transportation and Communications; (2) Construction; (3) Power; (4) Urban and Rural Engineering; (5) Sanitary Engineering; (6) Industrial Engineering; (7) Mining Engineering and Geology; (8) Teaching of Engineering; (9) Miscellaneous.

The procedure of holding technical meetings in Brazil, which is typical of all Latin America, is entirely different from our own and was new to most of our delegates. Each paper submitted to the Congress is referred to the appropriate Commission under which it belongs and a reporter is appointed to study it. The reporter presents his findings to the Commission, which then takes one of three actions: (a) the paper is recommended to be printed in full in the proceedings of the Congress; (b) the paper is recommended to be printed in abstract; or (c) the author is thanked for his efforts. The Committee's recommendations are submitted to a plenary session of the Congress, which, in most cases, automatically accepts the report of the Commission.

Other differences that might be noted between our technical meeting procedure and that in Brazil are the wide authority of the presiding officer to accept or reject a motion, even if properly seconded; and the almost unlimited debate that is allowed, calling for much patience on the part of those in attendance.

In closing this report, the writer wishes to express, on behalf of the United States delegation, its sincere appreciation of the unbounded courtesy and hospitality of its Brazilian hosts. Our delegates were enriched and stimulated by this opportunity of working closely and associating with the engineers of the other American republics.

Finally, the United States delegation unanimously recommends to Engineers Joint Council that it strongly urge its constituent organizations to study the proposed Constitution for UPADI and to take action to join that organization, whose purpose it is to unite with the other engineers of the Western Hemisphere in advancing the knowledge and the application of engineering techniques and to maintain that unity of professional understanding and action necessary to make effective the slogan of the First Pan American Engineering Congress, namely *"Engineering in the Service of Peace."*

Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Thursday, October 27, 1949, in the Hotel Muehlebach, Kansas City, Missouri. Those present were: Thorndike Saville, *President*, H. H. Armsby, F. M. Dawson, B. J. Robertson, F. E. Terman, J. S. Thompson, A. B. Bronwell, D. Daum, and J. I. Mattill (visitor).

Report of the Secretary

The Secretary reported that the official vote on the constitutional amendments was as follows: approved: 3151, disapproved: 53, undecided: 18. In view of the fact that the amendments have previously received the unanimous approval of the E.C.A.C., the E.C.R.C., and the General Council, they have been officially ratified by the Society.

The Secretary reported that the Membership Committee, consisting of a state chairman for each of the 48 states, had been appointed and that the state committees are being made up.

Report of the Treasurer

The Treasurer presented his report for the first quarter of this fiscal year showing that receipts from dues were somewhat greater than those of the corresponding quarterly period last year, while the disbursements are approximately the same. This report indicates that the Society finances will probably be in line with the budget. The Executive Board voted to approve the Treasurer's report and recommended that future budgets of the Society include an item for the annual audit rather than placing this in the contingency account.

Report of the E.C.A.C.

In conformance with the recommendation of President Saville to assign each Committee to report to one of the Councils, the Executive Board voted to assign the Committee on International Relations to report to the E.C.A.C. Vice President Terman suggested that this Committee might explore the possibilities of obtaining scholarships and fellowships for foreign students and prepare an article on this subject for publication in an early issue of the JOURNAL.

The Executive Board requested that the E.C.A.C. continue its manpower studies of the supply and demand of engineering college graduates on a basis similar to studies conducted during the past few years.

Vice President Terman discussed plans for the E.C.A.C. conferences at the annual meeting and suggested that since the employment situation for engineering college graduates will probably be acute, the E.C.A.C. might devote one of its conferences at the annual meeting to this question.

Report of the E.C.R.C.

Vice President Dawson indicated that copies of the 1949 "Directory and Review of Current Research," complete with index, are now available.

He also reported that conference programs at the Annual Meeting would be prepared by the E.C.R.C. Committees on Relations with Military Research Agencies, Relations with Non-Military Research Agencies, and Relations with Industrial Research Agencies.

Vice President Dawson reported that the proposal for the publication of a brochure which would present the reasons for emphasizing fundamental research in engineering colleges, as well as the benefits to be derived from such research programs, had been widely accepted. Publication of the brochure will be started in the near future.

Report of Vice President in Charge of Divisions and Committees

Vice President Robertson reported that the chairmen of Divisions and Committees have been asked to start working on their programs for the annual meeting. As a first step, letters have been sent to the chairmen requesting that they inform the Secretary as to how many conferences, luncheons, and dinners they would like to have at the annual meeting. As soon as this information is received, a tentative schedule will be prepared.

The Executive Board voted that as soon as the names of the conference speakers have been received, the Secretary should send each speaker, free of charge, a copy of the booklet prepared by the Committee on Relations with Industry entitled "Speaking Can Be Easy."

Vice President Robertson moved and the Executive Board approved that the Report of the Interim Committee on Young Engineering Teachers be sent to all deans of engineering colleges, with a letter recommending that the deans urge their younger faculty members to participate in activities of the Society through the Section meetings and the annual meeting of the Society.

Vice President Robertson pointed out that a number of Divisions and Committees of the Society have their own publications. These provide an outlet for the more highly technical papers which would not be of interest to the A.S.E.E. membership as a whole and therefore would not be published in the JOURNAL. These publications have been placed on a self-sustaining basis by revenue received from company advertising or sale of subscriptions to Division or Committee members. The Board felt that these publications were serving a useful purpose and should be encouraged, but pointed out that the JOURNAL OF ENGINEERING EDUCATION should have first priority on the publication of papers presented at Society meetings.

Summer Schools

Vice President Robertson reported that it has been the practice of the Society in the past to sponsor only one summer school each year. The question was raised as to whether or not the Society could provide a greater service by sponsoring several summer schools each year, assuming that each summer school would be placed on a self-financing basis. This would make it possible for each curricular group to hold a summer school every three or four years, rather than every ten or twelve years as has been the practice in the past. The Executive Board expressed approval of the multiple summer school plan.

The suggestion was made that consideration be given to setting up one or two summer schools devoted to the teaching of physics to engineering students. This possibility will be explored by Vice President Robertson and the Secretary. Additional suggestions for summer schools are reported in the minutes of the General Council meeting.

Report of Vice President in Charge of Sections and Branches

Vice President Armsby reported that a meeting of the Committee on Sections and Branches was held on October 27 at which preliminary plans were made for preparation of the proposed Sections manual. The Committee hopes to have this manual completed by the June meeting.

He also presented a recommendation of the Committee of Young Engineering Teachers asking that the Sections consider the "development of the young engineer" as a possible theme for their Section meetings. This report will be submitted to the Section chairmen.

Point IV

Vice President Armsby reported on his liaison activities to cooperate with the government on matters relating to the Point Four program, which is a long-

range program designed to help the backward countries of the world in developing their own economies. This program is still in the planning stage. Vice President Armsby reported that Mr. Green, of the Department of Commerce, who is in charge of the technical planning of this program, hopes that the Society will be sufficiently interested in the possibilities of this plan to appoint a committee which would draw up an outline showing what the engineering colleges might do to assist in the program. The Board voted to defer appointment of a committee until the proposed committee on relations with government is established.

Dates of 1951 Meeting

The Secretary reported that the A.S.M.E. and A.S.T.M. are holding their annual meetings in 1951 during the week of June 18 to 22 and that the A.I.E.E. is holding its meeting during the week of June 25 to 29. Since these are the only two weeks available for the 1951 annual meeting of the A.S.E.E., it appears inevitable that a conflict will occur. Since the dates of our 1950 meeting conflict with the summer meeting of the A.S.M.E., it was felt advisable not to conflict with their summer meeting in 1951. For this reason, the dates of June 25 to 29, as suggested by Michigan State College, were officially approved.

The Secretary of the A.S.E.E. has attempted to arrange a conference with the secretaries of the A.S.M.E., A.I.E.E., and A.S.T.M. to discuss the possibilities of scheduling meetings in June so as to avoid conflict in the future. The three societies have all expressed willingness to meet and discuss this problem, and a conference on this subject will be arranged during the coming year.

Publication of Papers of Graduate Studies Division

The Division of Graduate Studies requested permission to publish in booklet form papers presented at its conference on cooperative graduate level education between industry, colleges, and the government. According to the proposal, the cost of typing would be handled by Brooklyn Polytechnic Institute, and the cost of reproducing would be borne by the Society. The Executive Board felt that it would be inadvisable for the Society to start a precedent of publishing in booklet form the papers of Divisions, Committees, and Sections, and therefore voted not to make a special appropriation for the project. However, it was pointed out that the Division of Graduate Studies would be eligible to receive financial assistance from the usual budgetary allotment to Divisions and Committees.

Student Chapters

President Saville reported that many of the founder engineering societies have expressed concern over the efforts of other organizations to institute competing student chapters in engineering colleges. A new "Inter-Societies Conference on Engineering Student Branches" has been formed to study this set of general principles problem. The Society has been invited to be represented on this Conference.

The following additional items considered in the Executive Board meeting are reported in the minutes of the General Council:

1. Reorganization of Committees
2. Proposal for A.S.E.E. fellowships
3. Study of financing of higher education
4. Inter-relationships between subgroups of A.S.E.E. and other organizations
5. Proposal of Visual Aids Subcommittee
6. Duties of Secretary and Treasurer

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Minutes of General Council Meeting

A meeting of the General Council of The American Society for Engineering Education was held on Friday, October 28, 1949, in the Hotel Muehlebach, Kansas City, Missouri. Those present were:

Thorndike Saville, President
H. H. Armsby, Vice President
F. M. Dawson, Vice President (E.C.R.C.)
B. J. Robertson, Vice President
F. E. Terman, Vice President (E.C.A.C.)
J. S. Thompson, Treasurer
A. B. Bronwell, Secretary
D. I. Daum, Office Secretary
H. P. Adams, Technical Institute Division (representing K. L. Holderman)
H. W. Barlow, Aeronautical Division
H. J. Barre, Agricultural Engineering Division
L. R. Blakeslee, Architectural Engineering Division
H. R. Beatty, Evening Engineering Education Division
C. A. Brown, Michigan Section
M. E. Farris, Southwestern Section
C. J. Freund, Past President
R. P. Hoelscher, Engineering Drawing Division
H. K. Justice, Mathematics Division
R. D. Landon, Ohio Section
J. I. Mattill, Secretary, E.C.R.C. (visitor)
E. R. McKee, New England Section
M. B. Robinson, Cooperative Engineering Education Div.
F. L. Schwartz, Mechanical Engineering Division
J. E. Thornton, Social-Humanistic Division
J. K. Walkup, Industrial Engineering Division
K. F. Wendt, Mineral Engineering Division (representing G. J. Barker)
R. Z. Williams, Missouri Section

Reorganization of Society Committees

President Saville briefly discussed the reorganization of Society Committees whereby each Committee is assigned to report to one of the Councils and certain Committees which have discharged their responsibilities have been discontinued. He pointed out that the Society through its Councils, Divisions, and Committees had numerous relationships with the government which, up to the present time, have not been coordinated. He therefore recommended that a Committee on Relations with Government be established in the Society to serve as a coordinating committee. All activities of the Society relating to the government would then be cleared through this Committee before official action is taken. The Council voted to authorize such a Committee.

Acting upon the recommendation of the Executive Board, the General Council voted to discontinue the following Committees. In each case, the Past-Chairman of the Committee approved discontinuance of the Committee's activities: (1) Professional Development, (2) Teaching Manual, (3) Functions of the Vice Presidents, (4) Undergraduate Curricula.

As a further step in the reorganization of Society activities, President Saville reported that the Executive Board had recommended transferring the Committee on Selection and Guidance and the Committee on International Relations to the E.C.A.C. These recommendations were approved by the General Council.

Vice President Dawson reported that, at the suggestion of the Executive Board,

a representative of the E.C.R.C. would be appointed to correlate the graduate activities of the E.C.R.C. with those of the Division of Graduate Studies of the Society.

The suggestion was made that the Technical Institute Division and the Junior Colleges Committee of the Society have a great deal of common interest in their programs and activities and that they might be interested in consolidating to form a single Division. Professor Adams, Chairman of the Technical Institute Division, explained that the Technical Institute Division has recently been reorganized and that it was confining its attention entirely to the furtherance of the technical institute type of education as defined by the E.C.P.D. For this reason, he felt that the merger would be inadvisable. The matter was referred to the Technical Institute Division and the Junior Colleges Committtee for their consideration.

A.S.E.E. Fellowships

A proposal submitted by H. O. Croft, Chairman of the Committee on International Relations, to establish a program of international fellowships under the sponsorship of the A.S.E.E. was discussed. According to this plan, each university would set aside one or two scholarships or fellowships for international students. Also, funds might be obtained through U.N.E.S.C.O. or the Committee on Educational Reconstruction of the U. S. National Commission. The plan would be publicized through U.N.E.S.C.O. and their assistance would be solicited in preparing lists of eligible graduate students. The lists would be sent to the deans of engineering colleges and the official appointments would be made by the various colleges. Acting upon the recommendation of the Executive Board, the General Council voted to approve the plan in principle, subject to further improvement in the terminology and mechanics of the plan by the Committee on International Relations, and subject to subsequent approval by the Executive Board at its meeting in the Spring of 1950.

Committee Reports

1. *Interim Committee for Young Engineering Teachers*

Professor Schwartz, Chairman of the Interim Committee, discussed the written report of his Committee. He stated that the Committee is planning to hold one or two conferences for young engineering teachers at the annual meeting in Seattle, and the formal organization of a permanent Society committee will take place at that time. According to the recommendations of the Interim Committee, members of the Committee must be under 35 years of age and hold a rank lower than that of associate professor. Professor Schwartz suggested that his Committee could work most effectively through the Sections and Branches, and urged that those groups offer programs of special interest to younger faculty members and encourage the participation of younger members in their programs. It was suggested that Professor Schwartz write to the deans of engineering colleges in the West Coast area urging that they send some of their younger faculty members to the annual meeting. It was also pointed out that summer school activities of the Society should be planned so as to attract younger faculty members.

2. *Visual Aids Subcommittee of Educational Methods Division*

The written report of the Subcommittee on Visual Aids was discussed. This provided for a plan of accreditation of visual aids by committees chosen in each of the various curricula areas. The cost of accreditation would be sustained by participating companies, and a list of accredited visual aids would be published in booklet form for distribution to the engineering colleges.

Acting upon the recommendation of the Executive Board, the General Council voted to endorse the plan, subject to the

following conditions: (a) Because of legal connotations, the words "accrediting" or "approving" or similar terms should be avoided, although the Committee's plan to list the various visual aids which are useful in engineering instruction was approved. (b) The Committee was authorized to solicit funds from industry, provided that no expenditures shall be made from the fund until a sufficient amount has been raised to assure accomplishment of the initial objectives for which the funds were solicited. (c) The funds are to be deposited in a special account set up under the control of the Secretary and Treasurer of the Society. The plan of disbursements is to be approved by the Executive Board.

3. *Steering Committee on Improvement of Teaching*

The written report of the Steering Committee on Improvement of Teaching was discussed. The Secretary reported that a highly successful meeting of the Steering Committee was held in Pittsburgh on October 15 and that the objectives of the Committee have been fairly well defined. B. J. Teare, Chairman of the Steering Committee, will send to President Saville a list of persons who have been recommended by the Steering Committee to be added to the Committee on Improvement of Teaching.

4. *Enrollment Statistics Committee*

Vice President Armsby reported that forms for the collection of the enrollment statistics have been mailed to the deans of the engineering colleges. The U. S. Office of Education will collect and tabulate the statistics from all schools offering B. S. degrees in engineering listed on the U. S. Office of Education list, but the Society will publish detailed figures only on E.C.P.D. accredited schools, and totals for all others included in the U. S. Office of Education list. It was voted that the enrollment statistics be printed annually in the *Yearbook* issue of the JOURNAL, and that reprints of the statistics are to be included as a part of the bound Proceedings for each year.

5. *Teaching Manual*

The Secretary announced that the teaching manual had been completed and was now in the hands of the printer. Professor Morris, author of the manual, will complete publication arrangements.

6. *Speakers Manual*

The Secretary announced that the speakers manual entitled "Speaking Can Be Easy," prepared by the Committee on Relations with Industry, has been endorsed by the E.C.P.D. and a plan of distribution will be worked out in cooperation with the E.C.P.D. and the Committee on Relations with Industry.

7. *Constitutional Amendments*

The Secretary announced that the constitutional amendments have been ratified by vote of the general membership, as reported in the minutes of the Executive Board meeting.

8. *Division Status for Relations with Industry*

President Saville announced that the Committee on Relations with Industry had now obtained full Division status, in view of the recent ratification of the constitutional amendments and in accordance with the action of the General Council at its meeting on June 20, 1949.

9. *Census Committee*

President Saville called the Council's attention to the written report of Vice President Armsby as Chairman of the temporary Census Committee of the Society to collaborate with the Bureau of the Census in the recommendation of additional classifications of engineers to be used in census tabulations. Vice President Armsby stated that the recommendations of the Committee have been approved and will be put into effect.

Yearbook

The Secretary reported that the new format for the *Yearbook*, adopted by the Executive Board, would result in a savings of $700 annually on future issues. During the coming year, this savings will be offset by the increased cost of setting new type, since previous issues of the *Yearbook* have been printed from standing type.

Financing of Higher Education

President Saville reported that a substantial grant has been received by the Association of American Universities from the Rockefeller Foundation and the Carnegie Corporation to conduct an investigation of financing higher education. President Saville has contacted Dr. Millett, Director of the project, to investigate the possibility of A.S.E.E. participation in this project. Dr. Millett expressed interest in the possibility of having the A.S.E.E. conduct a survey of the costs of engineering education. Since plans for this project may crystallize in the near future, the General Council voted to authorize the Executive Board to collaborate with the Commission of the Association of American Universities and enter into a contract to carry on a study of the costs of engineering education if this action is deemed desirable by the Executive Board. In the event that this project is undertaken, it will be assigned to the E.C.A.C.

Revision in Nominating Procedure

The following procedure for the nomination of officers of the Society was approved by the General Council: (a) nomination ballots will be published in the December and January issues of the JOURNAL, with prominently displayed notice to members of the Society; (b) two informal ballots by letter will be taken by the Nominating Committee in March or April; (c) the Nominating Committee will meet on Monday afternoon at the Annual Meeting for the purpose of making final nominations; (d) the report of the Nominating Committee will be presented and election of officers will be held at the Wednesday morning General Session.

Annual Meeting

President Saville announced the plan of events for the Annual Meeting, which includes general sessions on Wednesday morning and Wednesday afternoon only, with a report on Society activities, the election of officers, and two addresses taking place at the general session on Wednesday morning. The E.C.R.C. and E.C.A.C. will hold general conferences on Tuesday and Thursday mornings, respectively, concurrently with non-conflicting conferences of Divisions and Committees.

The Secretary reported that at the Rensselaer annual meeting, abstracts of papers were mimeographed and made available at the door of each conference session prior to the meeting. This involved a considerable amount of work and a moderate expense. The question was raised as to whether or not the benefits derived warranted a continuance of this procedure. The Council agreed that this matter should be left to the discretion of the Divisions and Committees. If they wish to have copies of papers or abstracts available at the annual meeting, they will either request the authors to prepare these or make their own arrangements for the reproduction.

Additional suggestions were made regarding details in the conduct of annual meetings. These will be referred to the host institution.

Summer Schools

The Secretary reported that tentative proposals have been received for a summer school in mechanics at Iowa State College and a summer school in the social-humanistic field. It has also been suggested that summer schools be held on the teaching of engineering physics and English. The General Council voted to

authorize the Executive Board to approve such summer schools as it deems advisable.

The Council also voted that the Vice President in charge of Divisions and Committees undertake to organize a group to study the entire Summer School program.

Duties of the Secretary and Treasurer

Since the duties of the Secretary and Treasurer are not explicitly stated in the Constitution and By-Laws of the Society, the General Council, acting upon the recommendation of the Executive Board, authorized the continuance of the following procedures which have been in effect in the operation of the Society: (a) The Executive Board has final authority over all budgets, authorization of disbursements, investments, and other financial matters of the Society. (b) The Treasurer examines all monthly bank statements and the final audit, and is official advisor to the Executive Board in all financial matters. (c) The Secretary receives, disburses, and accounts for all funds of the Society; is responsible for all properties, including securities; submits quarterly financial statements to the Executive Board; and is responsible for having the books audited annually. (d) All checks and vouchers shall be co-signed by the Secretary and Treasurer of the Society. In the event of the absence or incapacity of the Secretary, the Assistant Secretary is authorized to co-sign checks and vouchers; in the event of the absence or incapacity of the Treasurer, the President is authorized to co-sign checks and vouchers. The Treasurer, Secretary, and those employees who handle funds shall be bonded at the expense of the Society.

The General Council requested that these procedures be referred to the Committee on Constitution and By-Laws for possible inclusion in future constitutional revisions.

It was also voted that Mrs. Dorothy Daum be appointed Assistant Secretary of the Society, such appointment to be on an annual basis.

Inter-relationships between subgroups of the A.S.E.E. and other organizations

In view of the increasing inter-relationships between subgroups of the A.S.E.E. and other organizations, the General Council, acting upon the recommendation of the Executive Board, voted that any cooperative undertaking between individuals or subgroups of the Society and other organizations should first receive the approval of the Executive Board. The Vice Presidents were requested to call this ruling to the attention of the various Society groups. This matter will be referred to the Committee on Constitution and By-Laws.

Unification of the Profession

As the A.S.E.E. representative to the committee of the Engineers' Joint Council working on unity in the engineering profession, President Saville reported that two tentative plans have been proposed: (1) To modify the constitution of the N.S.P.E. whereby registration will not be required for membership, and authorize this organization to represent the engineering profession in matters relating to government or the engineering profession as a whole. (2) To adopt a federated society plan, perhaps by expanding the E.J.C., to serve as an organization to unify the engineering profession.

President Saville reported that a subcommittee has been appointed to study this problem and make recommendations. This Committee will meet in January, and the Executive Board and General Council will be kept informed of developments.

Interpretation of Dues Rates

Acting upon the recommendation of the Executive Board, the General Council voted that members of the Society will qualify under the $5.50 and $6.00 dues status as listed in the Constitution and By-Laws only when their full-time services are related to the activities of educational institutions.

Life Memberships

The General Council voted that life membership should be granted to the following applicants, and the Secretary was instructed to notify these applicants of this action: Frederic Bass, J. L. Beaver, W. R. Bryans, A. M. Buck, Edwin F. Church, Jr., L. E. Conrad, T. T. Eyre, O. J. Ferguson, A. R. Keller, H. N. Lendall, F. W. Owens, John C. Parker, Harold Pender, John C. Penn, B. F. Raber, P. K. Slaymaker.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 13, 1950	D. S. Clark, Purdue University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
National Capital Area	Washington, D. C.	Oct. 4, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Fall, 1950	F. H. Thomas, University of Buffalo

Candid Comments

HOW TO WRITE A DIFFICULT LETTER

Dean ————
The University of ————
College of Engineering ————

Dear Dean ————:

Since I received your letter of May 8, I have been considering carefully your request respecting the recommendation of Mr. Blank. This letter is, therefore, not the ordinary type of recommendation but a sincere, definite, statement of facts regarding Mr. Blank who will receive his Master's Degree in Sanitary Engineering in June of this year.

I have known Mr. Blank since 1937 at which time he entered as a beginning student in engineering. I wish to be clear in that I am not recommending him as a top student scholastically but in all of the years of my teaching experience I have not found a young man who has done better under adverse conditions. He was greatly handicapped by having to earn a greater part of his expenses while in college and although he managed to get through it was not with a very good grade-point average. About a year before he was to be graduated, he was called to service as a private in the National Guard. He served all during the war and was discharged as a first lieutenant having been awarded the Silver Star, Purple Heart, and four or five unit citations. Since he returned to the University, the second semester 1945–46, his scholastic average has improved considerably and he has shown that he is capable of doing good work.

Now the real reason I am recommending him to you so strongly is that he took hold of a tough situation here in teaching surveying and also in assisting with other courses, and he did a reasonably good job. He is tall, well built, and is a good, though quiet, speaker. A year and a half ago he represented the University at a state honor meeting for engineering students and gave by far the best talk to the group. During the last two years he has been assisting in various capacities in teaching and in student activities. My only complaint about him is that he is somewhat retiring and does not give the appearance at first of being very keen and alert. However, this soon wears off because he is always on the job. If you are looking for a man in civil engineering who could teach sanitary engineering and practically any other subject in the curriculum of a more elementary type, I do not believe that you could do better than to suggest to the Department of Civil Engineering that they look seriously into the qualifications of Mr. Blank.

One of the things in his favor is that his wife is a very nice woman, they have three children, and they both can hold their own in any social gathering. If you are looking for a brilliant research investigator, then I would not recommend Mr. Blank; but if you are looking for someone who is a good teacher and who would have the respect of his students at all times, then he is as good as you will get. His broad experience on construction projects would be of help in any capacity. Although he is getting his Master's Degree in Sanitary Engineering, he has been broadly trained in all branches of the work in Civil Engineering.

Very truly yours,

————, Dean

New Members

AIRD, C. CLIFTON, Assistant Professor of Geology, Michigan College of Mining and Technology, Houghton, Mich. E. L. Wood, G. W. Swenson.

ALBRITTON, JACK H., Technical Instructor, Vocational Dept., University of Houston, Houston, Texas. W. B. Lowe, W. T. Kittinger.

ARTLEY, JOHN L., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. W. B. Stelzner, G. F. Branigan.

BARBER, CARL S., Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. H. C. Spencer, I. L. Hill.

BEATTY, JOHN M., Associate Professor of Structural Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. J. Kilcawley, J. S. Kinney.

BELANGER, ROBERT N., Instructor in Electrical Engineering, Michigan College of M. and T., Houghton, Mich. G. W. Swenson, V. O. York.

BIGGS, JOHN M., Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. M. J. Holley, Jr., H. J. Shea.

BIRD, GEORGE T., Assistant Professor of Electrical Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

BLAKELY, MATTHEW L., Assistant Professor of Civil Engineering, University of Connecticut, Storrs, Conn. K. C. Tippy, F. L. Castleman, Jr.

BODGER, W. KENNETH, Associate Professor of Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. W. E. Nudd, O. M. Stone.

BOKENKAMP, HARRY J., Instructor in General Engineering Drawing, University of Illinois, Champaign, Illinois. S. G. Hall, R. P. Hoelscher.

BOLTON, JOHN H., Bulletin Editor, Engineering Experiment Station, Iowa State College, Ames, Iowa. F. Kerekes, G. R. Town.

BRUNKEN, CARROL O., Instructor in Civil Engineering, University of Nebraska, Lincoln, Neb. G. C. Ernst, R. M. Green.

BUCHANAN, WALTER D., Assistant Professor of Drawing, University of Tennessee, Knoxville, Tenn. A. O. Webb, A. B. Wood.

BUCKLEY, ELERY F., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, T. S. Gray.

BULLOCK, REX G., Instructor in Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

BUTLER, STANLEY S., Instructor in General Engineering, University of Southern California, Los Angeles, Calif. P. H. McGauhey, R. C. Brinker.

CALHOUN, JOHN C., Associate Professor of Civil Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

CARPENTER, JAMES H., Manager, Engineering Training, Carrier Corporation, Syracuse, N. Y. L. Mitchell, J. A. King.

CASTELLANOS, LEO J., Assistant Professor of Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

CHAMBERS, CARLETON A., Assistant Professor of General Engineering, University of Southern California, Los Angeles, Calif. P. H. McGauhey, R. C. Brinker.

COWELL, SMITH E., Instructor in Physics, South Dakota School of Mines and Technology, Rapid City, South Dakota. R. H. Cook, E. E. Clark.

COWIN, JOHN W., Assistant Professor of Chemistry, Michigan College of Mining and Technology, Houghton, Mich. H. L. Coles, R. F. Makens.

CRUMP, JOSEPH R., Assistant Professor of Chemical Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

CUDD, JACK B., Technical Instructor, Vocational Dept., University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

DILLARD, JOSEPH K., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

DOBROVOLNY, JERRY S., Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill. E. D. Ebert, C. H. Springer.

DROUGHT, ARTHUR B., Assistant Professor of Electrical Engineering, Marquette University, Milwaukee, Wis. J. F. H. Douglas, W. D. Bliss.

DUNN, JOHN W., Associate Professor of Engineering, University of Wichita, Wichita, Kansas. K. Rozak, M. H. Snyder.

DURAN, SERVET A., Assistant Professor of Physical Metallurgy, State College of Washington, Pullman, Wash. E. G. Ericson, R. D. Harbour.

EATHERTON, LAUREL J., Instructor in Physics, South Dakota School of Mines and Technology, Rapid City, South Dakota. R. H. Cook, E. E. Clark.

ECKMAN, DONALD P., Teaching Fellow, Mechanics and Materials, Cornell University, Ithaca, N. Y. D. F. Gunder, H. C. Perkins.

ELROD, JOHN T., Professor of Industrial Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

ESHLEMAN, SILAS K., Associate Professor of Industrial Engineering, University of Florida, Gainesville, Fla. H. E. Schweyer, N. C. Ebaugh.

EVERETT, HOWARD C., Instructor in Civil Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

EYE, JOHN D., Lecturer in Civil Engineering, University of Southern California, Los Angeles, Calif. P. H. McGauhey, R. C. Brinker.

FAYRUM, RICHARD A., Project Engineer, N.E.P.A. Division, Fairchild Eng. & Airp. Corp., Pasadena, California. H. R. Kroeger, R. M. Boarts.

FITZHUGH, PARKER M., Technical Instructor, Vocational Dept., University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

FOOTE, EARLE G., Instructor in Mechanical Engineering, University of Washington, Seattle 5, Washington. B. T. McMinn, L. B. Cooper.

FRASER, BURT, Instructor in General Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

FRISCH, JOSEPH, Lecturer in Engineering Design, University of California, Berkeley, Calif. A. S. Levens, C. F. Garland.

FULLER, FERNLEY L., Assistant Professor of Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. K. E. Quier, A. W. Luce.

FURLEY, EDMUND, Instructor in Architectural Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

GAMBLE, CLYDE R., Assistant Professor of Mechanical Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

GARVER, GERALD H., Technical Instructor, Vocational Dept., University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

GERARD, GEORGE, Instructor in Aeronautical Engineering, New York University, New York, N. Y. F. K. Teichmann, G. H. Strom.

GOLDSTEIN, HAROLD, Chief, Occupational Outlook Branch, Bureau of Labor Statistics, U. S. Dept. of Labor, Washington, D. C. H. H. Armsby, Thorndike Saville.

GOOD, RAYMOND A., Assistant Professor of History and Geography, Michigan College of Mining and Technology, Houghton, Mich. E. L. Wood, A. K. Snelgrove.

GOODRICH, LYNN B. H., Instructor in Mechanical Engineering, University of Maine, Orono, Me. I. H. Prageman, H. D. Watson.

GRANT, HOMER H., Professor of General Engineering, University of Southern California, Los Angeles, Calif. P. H. McGauhey, R. C. Brinker.

GRECO, CARMELO S., Assistant Director, Connecticut Engineering Institute, Hartford, Conn. C. I. Burns, H. J. Lockwood.

GRONSE, EDWARD W., Assistant Professor of Chemical Engineering, Carnegie Institute, Pittsburgh, Pa. J. W. Graham, Jr., C. C. Monrad.

HALL, DAVID J., Associate Professor of Civil Engineering, University of Arizona, Tucson, Ariz. E. S. Borgquist, J. C. Parks.

HAMILTON, DEWITT, C., JR., Assistant Professor of Heat Transfer, Purdue University, Lafayette, Ind. O. W. Witzell, H. L. Solberg.

HAMMER, VERNON B., Instructor in General Engineering, University of Washington, Seattle, Wash. R. Q. Brown, D. C. McNeese.

HANNUM, FRANK W., Instructor in Mechanical Engineering, Michigan College of M. and T., Houghton, Mich. V. O. York, A. P. Young.

HARDING, ALBERT H., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, N. P. Bailey.

HAWKINS, ROBERT H., Instructor in Electrical Engineering, Purdue University, Lafayette, Indiana. G. V. Mueller, H. C. Johansen.

HEBERLING, WILLIAM W., Instructor in Electrical Engineering, Newark College of Engineering, Newark, N. J. S. Fishman, A. A. Nims.

HEITZMAN, EUGENE M., Instructor in Civil Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

HENDRICKS, JAMES W., Instructor in Drawing, University of Tennessee, Knoxville, Tenn. A. O. Webb, A. B. Wood.

HESSE, HENRY R., Instructor in Electrical Engineering, Cornell University, Ithaca, N. Y. J. G. Tarboux, W. H. Erickson.

HOLDEN, FRANK C., Instructor in Mechanical Engineering, University of Maine, Orono, Me. I. H. Prageman, J. F. Lee.

HOFF, JOHN E., Professor of Civil Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

HOUSTON, CARL P., Instructor in Industrial Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

JENNINGS, ROY T., Associate Professor of Engineering Mechanics, University of Florida, Gainesville, Fla. H. E. Schweyer, J. S. Johnson.

JOHNSON, HOMER F., Jr., Assistant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tenn. R. M. Boarts, H. J. Garber.

JOHNSON, PETER D., Assistant Professor of Ceramic Engineering, University of Washington, Seattle, Wash. A. B. Bronwell, F. B. Farquharson.

JORDAN, F. E., Assistant Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. J. A. Anderson, S. Osborne.

KINNEY, ROBERT C., Instructor in Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

KIRKPATRICK, C. U., Instructor in Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

KRAVIK, REUBEN C., Assistant Professor of Engineering, University of Minnesota, Minneapolis, Minn. M. S. Kersten, E. W. Johnson.

LAKE, WILLIAM H., Instructor in Drawing, University of Tennessee, Knoxville, Tenn. A. O. Webb, A. B. Wood.

LENOIR, JOHN M., Assistant Professor of Chemical Engineering, University of Arkansas, Fayetteville, Ark. M. E. Barker, W. B. Stiles.

LILLIOTT, RICHARD W., JR., Associate Professor of Architectural Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

LINSKY, CHESTER, Instructor in Mechanical Engineering, Bradley University, Peoria, Illinois. R. E. Gibbs, P. M. Green.

LNENICKA, WILLIAM J., Instructor in Civil Engineering, University of Nebraska, Lincoln, Neb. G. C. Ernst, R. M. Green.

LOWE, CLIFFORD B., Assistant Professor of Physics, South Dakota School of Mines and Technology, Rapid City, South Dakota. R. H. Cook, E. E. Clark.

MALLORY, WALTER F., Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. W. S. Beattie, A. R. Deschere.

MARSHALL, DONALD M., Instructor in Mechanical Engineering, University of Connecticut, Storrs, Conn. F. L. Castleman, Jr., C. H. Coogan, Jr.

MARSHALL, THOMAS G., Personnel and Placement Officer, School of Engineering, Oregon State College, Corvallis, Ore. C. O. Heath, Jr., S. H. Graf.

MCGEHEE, EDWARD M., Instructor in English, Carnegie Institute of Technology, Pittsburgh, Pa. J. W. Graham, Jr., A. Wright.

MCMAHON, THURMUL F., Assistant Professor of Civil Engineering, University of Kansas, Lawrence, Kans. D. D. Haines, G. W. Bradshaw.

MCMILLIN, EUGENE H., Instructor in Architectural Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

MEEKER, JACK A., Instructor in Mechanical Engineering, South Dakota School of Mines, Rapid City, South Dakota. E. R. Stensaas, A. R. Colgan.

MOSS, CARL R., Associate Professor of Engineering Administration, Michigan College of Mining and Technology, Houghton, Mich. R. F. Makens, D. E. McFarland.

NEWHOUSE, DEAN S., Dean of Students, Case Institute of Technology, Cleveland, Ohio. W. E. Nudd, O. M. Stone.

NEWTON, C. ALBRO, Associate Professor of Drawing, University of Tennessee, Knoxville, Tenn. A. O. Webb, A. B. Wood.

O'DEA, JAMES J., JR., Instructor in Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. J. Kilcawley, S. V. Best.

O'LEARY, JOSEPH A., Instructor in Mechanical Engineering, Washington State College, Pullman, Wash. E. G. Ericson, L. D. Luck.

PARHAM, GUY H., JR., Assistant Professor of Drawing, University of Tennessee, Knoxville, Tenn. A. O. Webb, A. B. Wood.

PAUW, ADRIAN, Assistant Professor of Civil Engineering, The Rice Institute, Houston, Tex. M. R. Marsh, L. B. Ryon.

PERNA, ANGELO J., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. L. S. Olsen, R. E. Bannon.

PLEHN, BRAINERD, Assistant Professor of Engineering, University of Santa Clara, Santa Clara, Calif. G. L. Sullivan, R. M. Hermes.

PLUNKETT, ROBERT, Assistant Professor of Mechanical Engineering, The Rice Institute, Houston, Tex. A. J. Chapman, C. R. Wischmeyer.

POLLACK, SIDNEY J., Tutor in the Mechanical Engineering Dept., College of the City of New York, New York, N. Y. S. J. Tracy, G. A. Guerdan.

POSSER, FRED H., Instructor in Mechanical Engineering, New York University, New York, N. Y. G. Kempler, A. H. Church.

PURNELL, WILLIAM B., Assistant Professor of Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

RASMUSSEN, ANDREW A., Professor of Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

RASS, HERBERT J., Manager, Employment, Allis-Chalmers Mfg. Company, Milwaukee, Wis. C. S. Haagensen, J. L. Singleton.

RATHE, ALEX W., Associate Professor of Administrative Engineering, New York University, New York, N. Y. D. B. Porter, J. M. Juran.

RED, DAVID G., Instructor in Architectural Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

REILEY, D. W., Instructor, Vocational Dept., University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

RENFREW, CLINTON A., Assistant Professor of Mechanical Engineering Dept., Norwich University, Northfield, Vt. W. D. Emerson, O. W. Bergethon.

RICE, ELBERT F., Instructor in General Engineering, Oregon State College, Corvallis, Ore. E. C. Willey, R. A. Wanless.

RIVELAND, ARVIN R., Instructor in Civil Engineering, University of Nebraska, Lincoln, Neb. G. C. Ernst, R. M. Green.

ROBERTS, JOHN P., Associate Professor of Metallurgy, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

ROSS, ANDREW W., Instructor in Civil Engineering, University of Arizona, Tucson, Ariz. H. H. Armsby, D. J. Hall.

SANDVIG, ROBERT L., Instructor in Chemistry, South Dakota School of Mines, Rapid City, South Dakota. J. W. Willard, G. G. Osterhof.

SCHIETINGER, JAMES R., Assistant Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md. J. T. Thompson, D. H. Fax.

SEARS, L. A., Associate Professor of Electrical Engineering, Michigan College of M and T., Houghton, Mich. V. O. York, A. P. Young.

SHAFFER, L. E., Professor of Mining, Head, Mining Dept., South Dakota School of Mines, Rapid City, South Dakota. W. E. Wilson, E. E. Clark.

SPAHN, GEORGE J., Assistant Professor of Civil Engineering, University of Dayton, Dayton, Ohio. L. H. Rose, A. J. Holian.

SUER, HERBERT S., Instructor in Civil Engineering, Kansas State College, Manhattan, Kans. F. F. Frazier, L. E. Conrad.

SULLIVAN, WILLIAM F., Instructor in Civil Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

SUMMER, JAMES R., Assistant Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J. B. H. Hershkowitz, T. A. Schneider.

SYLVESTER, ROBERT O., Assistant Professor of Civil Engineering, University of Washington, Seattle, Wash. R. B. Van Horn, R. G. Hennes.

TAYLOR, CLARENCE N., Instructor in Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, A. B. Bronwell.

TAYLOR, GEORGE A., Assistant Professor of Engineering and Management, Thayer School of Engineering, Dartmouth College, Hanover, N. H. W. P. Kimball, M. G. Morgan.

THOMAS, WILLIAM A., Associate Professor of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, C. W. Coppersmith.

THOMPSON, A. RALPH, Assistant Professor of Chemical Engineering, University of Pennsylvania, Philadelphia, Pa. R. E. Vener, M. C. Molstad.

THUERING, GEORGE L., Instructor in Industrial Engineering, Pennsylvania State College, State College, Pa. C. Bullinger, M. M. Babcock.

TIFFORD, ARTHUR N., Associate Professor of Aeronautical Engineering, Ohio State University, Columbus, Ohio. G. L. Von Eschen, F. M. Mallett.

TYLEE, ANDREW F. E., Head of Engineering Dept., Seddon Memorial Technical College, New Lynn, Auckland, S.W.4, New Zealand.

VARNER, WALTER W., Instructor in Applied Mathematics, University of Colorado, Boulder, Colo. G. Dobbins, W. K. Nelson.

VOGT, CHRIS. A., Associate Professor of Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, W. T. Kittinger.

WANG, CHI-TEH, Associate Professor of Aeronautical Engineering, New York University, New York, N. Y. F. K. Teichmann, G. H. Strom.

WEAVER, ARTHUR S., Instructor in Mechanical Engineering Dept., University of Maine, Orono, Me. H. D. Watson, I. H. Prageman.

WEBSTER, HERBERT L., Instructor in Mathematics, South Dakota School of Mines, Rapid City, South Dakota. G. W. March, W. E. Wilson.

WELLER, MONROE R., Instructor in Physics, Newark College of Engineering, Newark, N. J. I. P. Orens, H. H. Smith.

WHITAKER, THOMAS N., Assistant Professor of Electrical Engineering, University of Houston, Houston, Tex. L. L. Fouraker, H. C. Dillingham.

WILLIAMS, DAVID G., Assistant Professor of Engineering, University of Houston, Houston, Tex. W. T. Kittinger, W. B. Lowe.

WILLIS, MERTON J., Assistant Professor of Civil Engineering, Swarthmore College, Swarthmore, Pa. S. T. Carpenter, B. Morrill.

WILSON, GEORGE C., Instructor in Mechanical Engineering, University of Southern California, Los Angeles, Calif. P. H. McGauhey, R. C. Brinker.

WISEMAN, ROBERT S., Instructor in Electrical Engineering, Mississippi State College, State College, Miss. R. H. Guess, H. C. Simrall.

YOUNG, LYLE E., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. L. G. Palmer, H. D. Myers.

Total new members this year 351

Editorial—New Times Bring New Problems

By FREDERICK EMMONS TERMAN

Vice President of A.S.E.E. and Chairman, Engineering College Administrative Council; Dean of Engineering, Stanford University

The word "normal" is defined in the dictionary as "regular." As applied to engineering education, normal is a theoretical concept having very little practical significance. The only thing normal about engineering education is constant change and an unending succession of new problems.

This is to be expected, as technological progress consists of a steady stream of new developments. Unless engineering education keeps pace with technological advances, justification for professional training in engineering ceases to exist.

During the period between wars important changes took place in the pattern of engineering education. Fundamental science began increasingly to infiltrate into some fields of engineering. Graduate work, particularly at the master's degree level, became for the first time of substantial importance, and a few Ph.D.'s began to be turned out in majors other than chemical engineering. New fields of engineering, notably electronics and aeronautics, were born and rapidly grew to precocious maturity. The impetus given to the chemical industry by the first world war greatly enhanced the importance of chemical engineering. Finally, during this period a realization also developed that engineering alone was not enough, and that to make his full contribution to society, the engineer needed a background in the "humanistic-social stem."

World War II has left consequences in its wake which will drastically affect the future of engineering education. It has brought a great rise in undergraduate enrollment—over three times as many engineering seniors will be graduated in 1950 as in the peak year before the war. It has created a tremendous expansion in graduate work, and of research, in engineering colleges. It has greatly accelerated the previous trend toward emphasis on fundamental science in engineering, and it has changed the relative importance of many fields of engineering.

What does this mean for the future? Here are a few of the problems which will be confronting engineering educators in the next few years:

1. *The Trend of Undergraduate Enrollment.* There is every indication that undergraduate enrollment in engineering will fluctuate widely in the next ten years. The Bureau of Labor Statistics predicts that the number of engineering degrees awarded six years from this June will be only 40% of the present number, but that after 1956 there will be a steady and moderately rapid rise in enrollment. This presents budgetary problems, and raises questions as to what opportunities there will be for those who desire to enter the teaching profession during the next ten years.

2. *Employment Opportunities for Engineering Graduates.* A recent check indicates that the large number of engineers graduating in June 1949 have nearly all found employment. There may be a moderate surplus supply of engineering graduates in 1950, although there is a possibility that the excess of graduates over jobs will be smaller than had earlier been expected. The rapidly decreasing

enrollment after 1950, however, means that in a few years more there will again be a serious shortage of engineers. This will influence the number of students selecting engineering as a vocation; it will also affect the ability of universities to obtain and retain engineering teachers of high qualifications in competition with industrial opportunities, and so will act as an antidote for the otherwise depressing effect of decreasing enrollments on the teaching profession.

3. *Government Sponsored Research Program.* Is the present large volume of government sponsored research in universities a transient phenomenon, or can plans safely be made on the assumption that it will continue at a high level for considerable time?

4. *Graduate Work.* Graduate work has now become an important factor in the operation of many schools, both from the point of view of budgetary considerations and staff selection. The future of graduate work will be affected by the amount and kind of sponsored research that is available, and by the increasing financial needs of graduate students after the G.I. program has run its course. It will be greatly influenced by whether or not a government fellowship program is established.

5. *The Effect of Atomic Developments on Engineering.* The recent program sponsored by the Engineering College Administrative Council at Kansas City made it very clear that engineering educators can no more neglect the atomic age than can military planners. The atomic program is reaching a point where its problems are increasingly those of engineering, rather than those of pure science. In particular, chemical, metallurgical, sanitary, electronic, and heat-transfer engineers of the future should all have some background in radio activity. This possibly means that a review of the content of the fundamental courses in physics is in order.

6. *The Place of Engineers in Fields on the Border Line Between Engineering and Science.* An important question to be determined in the future is who will dominate the border-line fields between engineering and science, such as nuclear engineering, the more fundamental aspects of electronics, aerodynamics, etc. Will these areas become the province of the physicist who specializes in engineering physics, or will they belong to the engineer who emphasizes engineering science? This is an important question, since the fields under discussion represent areas of technological activity that are of great fundamental importance, and are expanding rapidly.

7. *How is the Undergraduate Engineering Curriculum to Include Everything That It Should?* The steady expansion of knowledge puts constantly increasing pressure on the undergraduate engineering curriculum and will force important decisions in the next few years. A possible solution is a five-year undergraduate program. An alternative is a four-year curriculum concerned largely with fundamental principles and with a humanistic-social flavor, followed by graduate study on the part of all of those who have a serious ambition to be professional engineers of a technical type. This latter plan is essentially the one now followed in chemistry and physics.

Time alone will give the final answers to the above questions. One thing is certain, however—that the administrative problems represented by these questions will provide plenty of work for these administrative officers who consider that part of their job to plan for the future. These men do not need to fear technological unemployment!

University of Washington—"The University of a Thousand Years"

By NATALIE COLES RUPP

Instructor, Humanistic-Social Department,
University of Washington

In mid-November, 1949, the people of the state of Washington were invited to attend a week-long open house on the campus of the University of Washington. Throngs of people investigated new buildings and equipment which are partial fulfillment of plans for the "University of a Thousand Years." The taxpayers were justifiably proud. And their pleasure and astonishment will be shared by visitors from all parts of the nation when the yearly convention of the American Society for Engineering Education begins here on June 19, 1950.

That the University of Washington should be host to the A.S.E.E. next summer is particularly appropriate, since in June a $21,500,000 post-war construction program, in which the College of Engineering has a share, will be nearing completion. While obtaining tremendous material gains, the University has maintained its high educational standards, and, with an enrolment of 16,380, has taken its place among the top universities in the United States.

Visitors next June will see a campus of 40 major buildings, costing about 30 million dollars, on a 600-acre site, with library, scientific equipment, and utility apparatus costing another three and three-quarter million dollars. Yet less than one hundred years ago the University of Washington was only an idea, discussed in the legislature of what was then the Washington Territory.

Beginnings

In the spring of 1861 three forward-looking citizens of Seattle deeded 10 acres for a university; on November 4, the University of Washington opened. The 22-year-old "principal," Asa Shinn Mercer, had one building, one teacher, and the grand total of 31 students, mostly recruited from near-by logging camps. We should note that at this time Seattle boasted less than 200 citizens, not counting Indians; only 11,000 people lived in the entire Washington Territory. In the beginning most of the students were taking secondary subjects. Courses were soon offered in Greek, Latin, mathematics, spelling, and penmanship; grades were also given in "promptness," "posture," and "cooperation."

Four times in the next 16 years the infant university closed, sometimes for a few months, sometimes for more than a year, because of a lack of students or a lack of funds—or both. At one crucial point a prominent settler, Henry Yesler, proposed to raffle his sawmill and brewery to obtain funds, but the community objected to financing by a lottery, and the plan had to be dropped.

In spite of setbacks, the westerners were not easily discouraged. Throughout the entire United States, pioneer settlements have been quick to recognize education as essential to their advance. And the same pioneer spirit for culture which had characterized New England in its early days now dominated the Northwest. In 1877 the University reopened after being closed for several months "on account of poverty," never to be closed again. On November 11, 1889, Washington was admitted to the Union, and the University of Washington, automati-

cally becoming a state institution, was well on its way with an enrolment of over one hundred students.

By the following year, the University had outgrown its original campus, which is now the center of downtown Seattle. In fact the Olympic Hotel now stands on the ground once occupied by the first University of Washington building. A.S.E.E. visitors who stay at the Olympic Hotel may be sleeping or eating in the very space where once was taught penmanship or Greek.

In 1895 the University moved to its present 600-acre campus, between Lake Washington and Lake Union. A happier choice of location could not have been made, for the University of Washington, nearly surrounded by water and with snowcapped Mt. Rainier and the Cascade range as a backdrop, is considered one of the most beautifully situated in the country.

Growth

In the decades which followed, the new campus grew rapidly. Often students and faculty, dressed for work, turned out with axes, picks, shovels, and rakes to help clear wooded areas and to make the natural beauty of the campus more available. Then came the Alaska-Yukon-Pacific Exposition of 1909. The dean of Mines had called attention to the desirability of holding the exposition on the campus. Accordingly, land was cleared and graded; buildings were erected. Professor Milnor Roberts, Dean Emeritus of the College of Mines, has written:

> The Alaska-Yukon-Pacific Exposition, held in the summer of 1909 to call the world's attention to the development of the Pacific Northwest that had resulted from the discovery of gold in the Yukon Territory and Alaska, not only spread the name of the University of Washington over the country but was of direct benefit to the institution and especially to the engineering departments. . . . At the close of the Exposition the University took over the five new buildings of brick construction and also 23 structures of more or less temporary character . . . during the rapid growth in student enrolment for the next few years, these buildings were the salvation of the University.[1]

The most spectacular and important building development has taken place since the end of World War II. The $21,500,000 building program has advanced to the point where returning graduates of only a few years back get hopelessly lost hunting the old familiar landmarks. And plans are ready for an additional twenty-million-dollar program.

Among the new buildings which visitors will see next summer are the Administration Building, a graceful five-story structure of gray cast stone, the Art and the Music Buildings, and David Thompson Hall, all matching the traditional collegiate Gothic plan of the older buildings. The largest and most costly structure is the nine-million dollar Health Sciences Building of modern design, where are housed the new Schools of Medicine and Dentistry.

A.S.E.E. members will be particularly interested in the new Electrical Engineering Building and Charles Church More Hall (Civil Engineering), both of modern functional design, and the Nuclear Research Building, housing the University's 200-ton, 60-inch cyclotron, recently completed at a cost of $300,000.

The Fisheries Building, now under construction, will contain facilities for various state, federal, and international services, with provision for hatcheries and rearing ponds. Also completed are a Botany Greenhouse and new additions to Physics Hall, Johnson Hall, and the majestic Henry Suzzallo Library. A $2,500,000 addition to the University Power House is still under construction. Nor would crew enthusiasts allow us to forget the Conibear Shell House, which provides space for 24 rowing shells and a workshop for George Pocock, master boat builder, as well as locker rooms, showers, dining room, and kitchen.

From the students' point of view, the

[1] Milnor Roberts, *History of the College of Mines*, University of Washington, 1936.

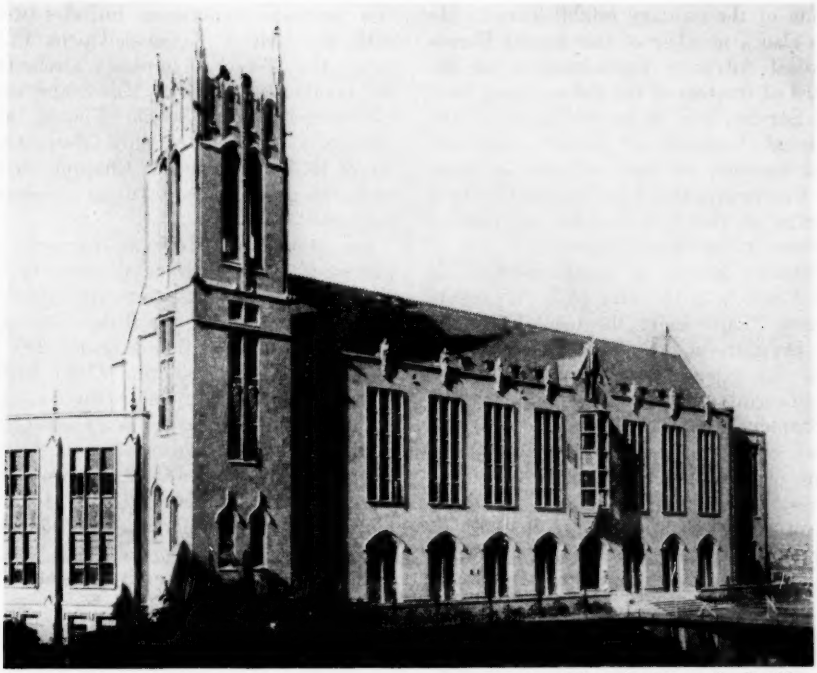

Photo by James O. Sneddon

Administration Building

most exciting development has been the completion of the first two wings of the Student Union Building, which will eventually be a five-wing structure costing over three million dollars. This long-awaited center is designed to accommodate every type of student activity and recreational program. Now containing offices, conference rooms, a large lounge, a cafeteria, snack bar, and several dining rooms, the completed Student Union Building will include such facilities as bowling alleys, a ballroom, a theater, hobby-craft rooms, and—a barber shop!

Faculty

In spite of these rather dazzling figures, we realize that the "University of a Thousand Years" means a great deal more than buildings and other material benefits. With its near-record enrollment of 16,380, the University of Washington has now a faculty numbering 903 full-time persons. This figure is the highest in the University's history, but it is not important for that reason. For the first time since the war the student-faculty ratio is below 20 to 1. In 1946, as post-war enrollment skyrocketed, the ratio reached 26 to 1, about twice the normal prewar national average. Now with a ratio of 19.5 to 1, the University approaches the 18–1 ratio set as a goal for the present biennium.

Faculty additions during the past few years have brought to the campus a number of men outstanding in their fields. Formerly executive dean of the Chicago colleges of the University of Illinois, Dr. Raymond B. Allen became president of the University of Washington in September, 1946. President Allen has served upon the boards of many local, state, and national organizations. He was a member of the Eberstadt subcommittee of the Hoover Commission, handling unifi-

cation of the military establishment. He was also a member of the Armed Forces Medical Advisory Committee, is on the board of trustees of the Educational Testing Service, and is on the board of the national Institute of Pacific relations. Last summer, on leave of absence from the University, Dr. Allen served for three months as the first director of medical services in the armed forces.

Already known to many members of the A.S.E.E. is Dr. Harold E. Wessman, former Chairman of the Civil Engineering Department at New York University, who was named Dean of the College of Engineering on June 12, 1948.

Stanley Chapple, internationally famous orchestral conductor, recently became head of the University's School of Music, succeeding the late Carl Paige Wood. Dr. Chapple came to the University after three years as conductor of the St. Louis Philharmonic Orchestra. His previous experience includes work with the British National Opera Company, the London Symphony Orchestra, the London Academy of Music, and various orchestras in Berlin, Vienna, and Warsaw. At the Berkshire Music Center in 1939 and 1940 Dr. Chapple served with Serge Koussevitsky as associate conductor.

Dr. Robert B. Heilman, formerly of Louisiana State University, came to the University in 1948 as executive officer of the Department of English. This department was made famous in the 20's by Vernon Louis Parrington (1871–1929), historian and critic, whose three-volume *Main Currents in American Thought,* one of the foremost interpretations of American literature and thought, won the Pulitzer prize in history. Dr. Heilman himself is widely know as an educator and a writer.

In spite of the University's location in

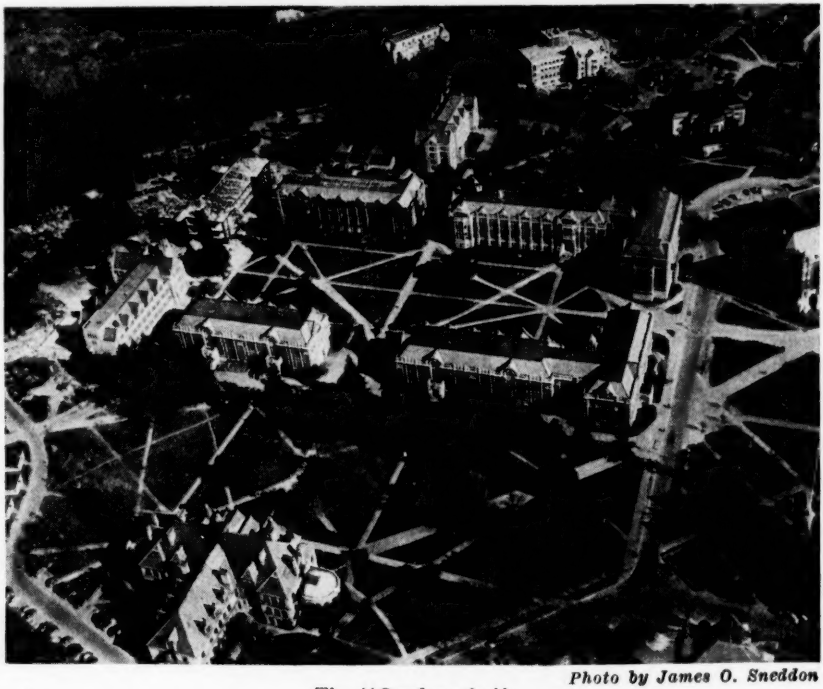

Photo by James O. Sneddon

The "Quadrangle."

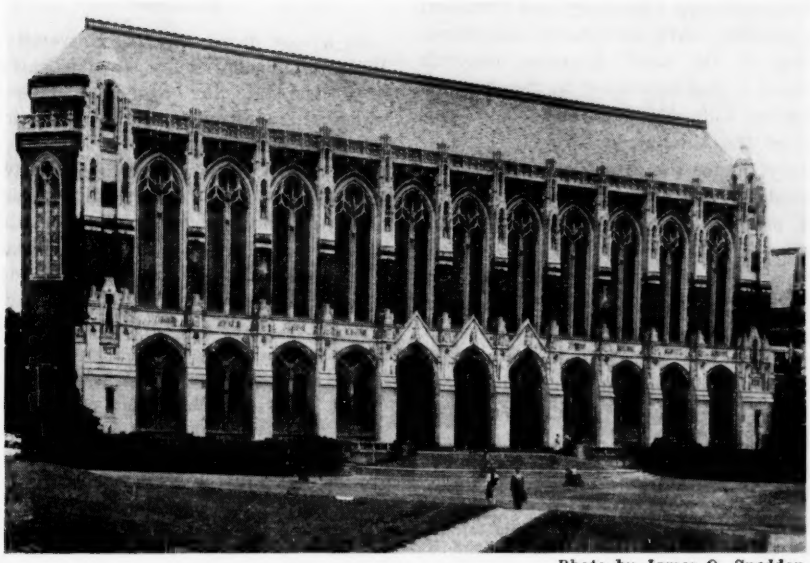

Photo by James O. Sneddon

Henry Suzzalo Library

the Northwest corner of the United States, its faculty and staff can scarcely be accused of provincialism. Dr. Wilbert M. Chapman, Director of the School of Fisheries, is now on leave of absence serving as a Special Assistant to the Undersecretary of State in Washington, D. C. Dr. Nathanael H. Engle, Director of the University's Bureau of Business Research, has served for some time on the Advisory Committee to the Office of Small Business of the U. S. Department of Commerce. Dr. George E. Taylor, Director of the Far Eastern Institute has served periodically as a Consultant to the U. S. Department of State.

Research

The outstanding quality of the staff as a whole has brought to the University more than $3,000,000 in research grants from federal, industrial, and scientific agencies during the past five years. Much of the industrial research at the University of Washington is conducted or financed through the Engineering Experiment Station, established thirty years ago to aid in the industrial development of the nation and to publish information on engineering problems useful in municipal, rural, and industrial areas. The station includes nine divisions: Forest Products, Mineral Engineering, Aeronautical Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Geology, and Physics Standards and Tests.

Industrial research at the University is directed principally toward solution of problems of major regional interest. For example, a new electronic microscope purchased by the University gives promise of answering problems that have baffled wood technologists for years. The College of Forestry is conducting research in forest soils and in certain aspects of forest-fire protection. In 1944 a Pulp Mills Research Project was established to discover uses for waste products of the pulp and paper industries, and a number of technical depart-

ments, including Chemistry and Chemical Engineering, have contributed assistance.

One of the most dramatic research projects is that conducted by the Applied Fisheries Laboratory. Since the beginning of the Manhattan Project, this laboratory, under the direction of Dr. L. R. Donaldson, has carried on an investigation of the effects of radioactivity on marine life. Dr. Donaldson and members of his staff were present at the Bikini "Operation Crossroads" experiments in 1946; a series of resurveys of Bikini followed. Last summer's expedition was considered the most satisfactory of all. The group of twelve scientists and specialists not only made a new examination of the radioactivity still remaining in Bikini's life system, but also collected observations and specimens which are expected to yield new clues to the behavior of radioactivity in a natural environment. (See *Life,* November 21, 1949, pp. 133–6.)

Other significant research projects—to name but a few—are the School of Medicine's work on cancer, diphtheria, and the Rh factor in the blood cells, and the Physics Department's nuclear research, now to be tremendously expanded by the newly completed cyclotron.

Services

In a very direct way the University of Washington contributes to the cultural life of the state, far beyond the classroom walls. In addition to its Department of Correspondence Study, Department of Extension Classes, Office of Lectures and Concerts, and Community Forum Program, the University has something rather unusual—a Touring Theater, which reaches about 100 cities during a season. Plays are presented by University drama students for both adult and high-school audiences of Washington towns. A new Instructional Materials Center provides films and other audio-visual materials not only for University classes but also for schools and adult groups through the state. The Office of Circulating Exhibitions, organized in 1948 under Melvin Kohler, curator of the Henry Art Gallery on the campus, prepares art exhibits for schools and commercial groups.

More, much more, could be written, about the world-famous Showboat and Penthouse Theaters, the Henry Art Gallery, and the beautiful and unusual Washington Arboretum. However, when the A.S.E.E. convenes in June, 1950, visitors will have a chance to see for themselves the "University of a Thousand Years."

Proceedings Available

Copies of Bulletin No. 29, "Proceedings of the Symposium on Engineering Research" held at the University of Minnesota in March, 1949, are available free of charge to administrators of educational institutions and directors of research organizations. A copy may be obtained by writing to Professor C. E. Lund, Assistant Director, Engineering Experiment Station, University of Minnesota, Minneapolis 15, Minnesota. Additional copies will be furnished at a nominal cost.

Differentiating Characteristics of an Engineering Curriculum

By S. C. HOLLISTER

Dean of Engineering, Cornell University

EDITOR'S NOTE: *The following statement, prepared by Dean Hollister and adopted by the Committee on Engineering Schools of the Engineers' Council for Professional Development, was presented at the Annual Meeting of the E.C.P.D. in Chicago, October 29, 1949. It is followed by a discussion by Dean Hollister. Comments on this statement are welcome and should be sent to the Secretary of the A.S.E.E. for publication in the "Candid Comments" section of the* JOURNAL.

There has been a steady increase in specialized branches of engineering during recent years. Some of these are simply specializations in functional engineering, such as welding engineering, tool and die engineering, petroleum engineering and refinery engineering. Others are associated more closely with the basic sciences, as, for example, geological engineering or engineering physics. Still others tend toward the border line of business, such as administrative engineering or general engineering.

Many engineering schools have catered to the popular demand for specialized training in a wide variety of engineering specialties. As a result there exists today some confusion as to what really characterizes an engineer, or indeed a curriculum suitable for training for any of the branches of engineering. It appears timely, therefore, to examine this situation and to prepare if possible a compact statement of what characterizes *engineering* training. In fact, if acceditation is to be successful, curricula so accredited must contain such characteristics as may readily identify them as *engineering* curricula.

Boundaries Between Engineering and Contiguous Fields

Engineering education is surrounded by other educational operations. It will be helpful to explore the boundaries between engineering and those contiguous fields in order that a clearer understanding of engineering education may be had. It would be hoped that such a process of boundary exploration would eventually so circumscribe the training and function of the engineer as to make it feasible to undertake a direct definition of the characteristics of an engineer.

It is generally accepted that engineering training is at the college level. Thus one segment of its boundaries would be represented by the trade school, the technical institute, and the general secondary school. Within the collegiate area it is bounded by programs in the liberal arts, in science, in business, architecture, agriculture, etc.

Boundaries between college and secondary schools or trade schools are well defined. Similarly the technical institute operating at post high school level is readily distinguished from engineering training at college level. Confusion arises in varying degrees between engineering training and other college work. Particularly it arises in curricula which are in part engineering and in part other college subjects.

It should be stated clearly that this discussion does not undertake to evaluate

curricula which are in part engineering and which are heavily charged with work in business, liberal arts or some other field. Such courses are highly desirable and more of them should be given. The sole problem considered here is whether such curricula should be considered as *engineering* curricula leading to an *engineering* degree. This calls for a specification of *differentiating characteristics contained in an engineering curriculum.*

Comparison of Science and Engineering Curricula

A comparative study of curricula in science programs with those in engineering reveals a significant difference between the two groups of curricula. It is characteristic of the engineering programs that mechanics, mechanics of materials, and courses in the properties of materials be included. Based upon such courses, it is also characteristic that in varying degree there will be courses relating to structures, apparatus, or machines, and the principles upon which they are designed, constructed and operated. Such courses are not found in the science curricula. For example, a curriculum in mining engineering will include mathematics, physics, chemistry and geology as will also a curriculum in geology. But the mining engineering curriculum also contains courses in mechanics, hydraulics, hydraulic machinery, heat engines and electrical equipment. The inference is that the mining engineer is going to design, construct, and operate and that the geologist is interested in the formation and nature of the earth's crust but that he is not intending to design, construct or operate works either above or below ground.

When curricula in engineering and in architecture are compared, courses in mechanics and materials and sometimes in structural design are found in the architectural program. The principal characteristic of the architectural curriculum, however, is training to achieve artistic excellence in the proportions of parts and in the decorative treatment of structures. In practice the architect emphasizes function and beauty, whereas the structural engineer emphasizes function and safety. The two fields obviously lie very close together, and it is conceivable, and in fact is occasionally true, that the architect may act as a structural engineer, and vice versa.

A comparison of curricula in electrical engineering and in physics reveals the characteristic presence in the engineering curriculum of mechanics and materials of engineering. The physicist ascertains the behavior of physical phenomena in terms of physical principles and, generally speaking, is not concerned with design of machinery and apparatus for manufacturing purposes. The engineer, on the other hand, is applying the principles of physics in the creation of machinery and apparatus for manufacturing or other useful purposes.

Distinguishing Characteristics of an Engineering Curriculum

Throughout these differences of characteristics noted between the engineer and a person in an adjoining field, one finds *ability to design* as a significant and distinctive element. The process of contriving a scheme, system or concept of a device, together with a forecast of behavior thereof, which if built would be appropriate to the functional, economic and safety requirements, is here meant as design. An engineer, for example, *designs* a bridge by first *analyzing* the conditions and functions to be satisfied; and secondly, by *synthesizing* from his knowledge of foundations, loadings, construction methods, mechanics, properties of materials, traffic requirements, economic considerations, financing, etc., the elements appropriate to this particular structure.

It may now be stated that:

An engineer is characterized by his ability to apply creatively scientific principles to design or develop structures, machines, apparatus or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same

with full cognizance of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economies of operation and safety to life and property.

The function of design is not limited to machines and structures. Process design may be defined briefly as the determination of the best process to accomplish a given end from the standpoint of economy, safety, and available raw materials and equipment. Courses in engineering application, therefore, which supplement those in applied science for full development of design qualifications are not limited to machine or structural design, but include production processes.

A curriculum which adequately trains a man to become an engineer must furnish the technical background, and should supply also the general training, for the *process of analysis and synthesis essential to designing.* There is the question, however, as to what may be considered an *adequate* training in the various essential features of the curriculum.

All engineering curricula may be divided into five sections as follows:

1. Basic science (mathematics, physics, chemistry, biology)
2. Applied science (mechanics, thermodynamics, fluid mechanics, aerodynamics, geology, properties of engineering materials, etc.)
3. Applied engineering courses (as for instance internal combustion engines, machine design, structures, industrial electronics, plant layout, etc.)
4. Administrative and managerial (cost control, quality control, industrial organization, labor relations, etc.)
5. General (liberal courses designed to provide a general educational background)

Mathematics, physics, chemistry and biology are the fields of basic science which form the foundation of engineering training, in amounts appropriate to the particular branch of engineering.

Whether administrative and managerial subjects or courses relating to general educational background are included in the curriculum is not essential to our present study because they do not contribute to those peculiar characteristics which differentiate the engineer from his lay-fellows. These do, however, contribute broadly to development of those qualities of professionalism which characterize the engineer capable of large engineering works, especially when such subjects are reinforced by broad attitudes and inspiration of the teaching staff.

Preparation for any form of design originates in the basic science courses, and is governed not alone by what science courses are included, but also by the depth of such courses and the extent to which they are interwoven into subsequent courses in applied science and engineering. For example, mechanics taught without calculus results in much less design ability than mechanics taught with calculus. Similarly, electrical theory taught without differential equations and Fourier's series develops much less power of analysis and synthesis than would have been the case had these two branches of mathematics been employed. The level of course content, and thus of training, is usually set by the depth of training in the basic sciences and what is equally important, the extent to which these permeate the subsequent courses.

Supplementary Discussion

No attempt has been made to describe all of the functions that engineers may perform in the course of the practice of engineering. Instead, the differing characteristics have been sought, by which the engineer's work may be recognized from the work of others. A common definition of an engineer frequently quoted is that he is "one who directs the forces of nature to create useful things." Such a statement would not, for example, exclude the architect or the agriculturalist.

Many of the engineer's functions overlap those of others, and thus are not in themselves distinctive characteristics of engineering. The engineer directs men; so do persons in many other professions and callings. He applies principles of economics and finance; so do business men and bankers. What is here sought is that characteristic which includes all kinds of engineering but which excludes all but engineering.

It is in part a characteristic of the engineer that he applies scientific principles in design, construction and operation. This differentiates him from the artisan, who constructs or operates without scientific knowledge. The engineer, furthermore, constructs and operates within the framework of limitations inherent in the design; and to do such constructing and operating he must be fully conversant with the design and its limitations.

It is not an essential that in order to be an engineer one must be engaged in designing. It is essential that a knowledge of design be had, based on the application of scientific principles. Such design is not aimed primarily at aesthetic or functional objectives alone, but in addition characteristically includes objectives involving economics and safety. The economic objective in part distinguishes the work of the engineer from that of the scientist or the artist.

It is recognized that the words "design" and "designer" mean different things to different people. They are not here used in the narrow sense usually attached to them in engineering offices, where some are "designing," some "detailing," others "developing," and so on. The whole creative process, extending from the initial conceptual thought to the subsequently refined final plan is here meant as design. It may be achieved by mathematical or developmental procedures, but it utilizes scientific principles.

There is real danger in undertaking to be specific as to the characteristics desirable in any professional program, because there is the possibility of too literal a translation of such a statement into courses rather than into guiding principles. The Committee is fearful that the mention of "design" might suggest to some the thought that what is desired is a certain number of credit hours in one or more courses labeled "design." This is not what the Committee has in mind. Rather, it hopes that "design" will be regarded in a broader and more fundamental way, involving the development within the student of original, resourceful, creative ability. Such an achievement results perhaps more from the nature of the teaching than from course outline. It becomes a way of education.

College Notes

Dr. Clayton O. Dohrenwend, graduate of **Rensselaer Polytechnic Institute** in 1931, has returned there with the full rank of professor to succeed Professor LeRoy W. Clark as head of the Department of Rational and Technical Mechanics. During the interim he is making a study of the department and will contribute to the planning of the Institute's research program.

The Factors Affecting Industrial Activity[1]

By C. H. GREENEWALT

President of E. I. du Pont de Nemours & Co., Wilmington, Delaware

I am very glad to have the opportunity of speaking to you this morning; first, because I am in complete accord with the desirability for close and sympathetic association between industry and education and, second, because of the important role you, as educators, can play in reawakening in our youth understanding and whole-hearted support for the high principles which have made our country a great nation.

Most young people now graduating from our colleges are entering a world in which the traditional guideposts have become obscured. Throughout their entire lives they have been living in a kind of intellectual no-man's land across which social and economic conflicts have raged.

Many of them are approaching their adult lives with a background of misunderstanding and mistrust of the system which offers them opportunity. That they should question is right and proper, but that they should question in an atmosphere of ignorance and bewilderment is unthinkable and dangerous.

If we are to preserve the freedoms which have made us great, we must be very clear as to what they *are* and what they *mean,* for it is only in that way that we can avoid the creeping socialism whose waters have nearly submerged Great Britain and are now rising about us in this country.

I was asked by your committee to speak on "The Factors Affecting Industrial Activity" and you may think this is a queer way of opening that discussion. I think we must all realize, however, that industrial activity, as we know it here, is the *effect,* not the cause, and if we do not safeguard our individual liberties, we will soon have no industrial activity to discuss.

It is unfortunate in a sense that we are a nation that appears to delight in sixty-four dollar words. We say "presently" when we mean "now"; we say "mortician" when we mean "undertaker"; we say "a sufficiency of" when we mean "enough."

In speaking of econonic systems we talk about "socialism" and "communism" when we mean "bondage." We talk about "free individual enterprise" or "capitalism" when we mean "freedom." The simple words are best. They draw the issues clearly and unequivocably, and we befog our own minds when we talk in any other terms.

Basic Premise of Democracy

Nearly two centuries ago, this country was founded on one very simple premise: that it was the individual who was important—that he was to be free to pursue his own destiny to the fullest extent of his abilities and to retain for himself the fruits of his labors.

With that simple and positive statement there went but one prohibition—that no individual or group of individuals should be allowed to interfere in any way with the right of their neighbors to the enjoyment of those liberties.

We have accumulated over the years a great body of law that enforces that

[1] Presented at a General Session at the 57th Annual Meeting of the A.S.E.E., Troy, N. Y., June 24, 1949.

prohibition because as a people we have traditionally feared power and its potential misuse. And yet we face today the curious anomaly that we have vested in our government power over our lives and freedoms far greater than was ever held by an individual or a business or a labor union—power so great that it can, if not curbed, destroy our way of life.

I should like to emphasize once more that our industrial system is the *result* of the exercise of that freedom carved out for our citizens so painfully, so many years ago. We could have developed in any direction we chose. Our statesmen in those early days never contemplated an industrial economy. They expected us then to become primarily an agricultural nation. We could have, had we wished, fulfilled that expectation, or we might have developed in many different directions and still become a great nation.

The fact is that we, a free people, *elected* to go after the material things we now enjoy, and because we were a free people we attained that objective to an extent never before witnessed in the history of the world. We have had the privilege of self-determination, we have had the prohibition that brooked no interference with that privilege, and we have become great.

But today many of us appear to be demanding guarantees that this high standard of living will be forthcoming from the cradle to the grave, no matter what our abilities, no matter what our contributions to the common good. In that demand lies great danger, for there can be no guaranteed security that does not come sooner or later in conflict with individual liberty.

Guaranteed security means simply that what you do not do for yourself will be made good by legalized piracy practiced on your more able neighbor.

I think that right here we must draw a sharp distinction between what we should like to do and what we actually can do. All of us would like to see security for every man, woman, and child in the world. No one is in favor of privation. But we must realize that no government has resources that do not come from its people; no government can undertake to pay someone without at the same time taking from someone else. When a government undertakes to guarantee security, health, or any other so-called social benefit, it is simply guaranteeing that it will rob Peter to pay Paul.

Hazards of Guaranteed Security

Guaranteed security is an attractive doctrine but a dangerous one. No such guarantees have ever been made good in a long history of attempts by many governments over many generations. Those attempts have led ultimately to the removal of individual incentive and, with incentive gone, there can be no progress.

The material well-being we now enjoy is based upon our productive capacity—on the tools through which man's ability to produce has been increased a thousandfold. Archimedes once said that with a lever sufficiently long, he could move the world. We in this country have done just that, and our lever is the tools with which our productivity has been infinitely multiplied. Those tools, which are the industrial wealth of this country, represent the thrift and self-denial of its citizens over long years of history. And back of that willingness to save was the hope of a profit through which those thrifty ones could enjoy the only real security with any prospect of being permanently fruitful.

Let me repeat. Progress comes through increased production. Production is increased through the provision of tools with which to multiply the inconsequential output of our hands. Tools are provided through self-denial and thrift in the hope of permanent security through profit. So the system we have today and which, God willing, we can preserve for all time, is the incentive of enlightened self-interest. With that incentive before us there are no heights to which we cannot rise. With that incentive removed, one has only to look at recorded history

to see the quicksands into which we will sink.

Evidence of Success of Profit System

There are many ways in which I could express the gain in material well-being our system of enlightened self-interest has brought us. We have 6% of the world's population but we have substantially one-half of the world's wealth and income. Four-fifths of our families own automobiles; 90% have homes wired for electricity; 95% have radios; more than 95% have telephones.

Fifty per cent of our families own their own homes; 85% of the entire national income is received by 90% to 95% of the entire population; 78 million people have provided for their own security by owning insurance policies with a maturity value exceeding 200 billions of dollars. These are material benefits.

But we are also the healthiest nation in the world and under a system of *private* medical service. Our span of life has increased 36% in little more than a generation, and each child at birth has a life expectancy of nearly 70 years.

We are well educated, too. We provide a free high school education for every boy and every girl in the country, and a college education for millions of people each year.

We have more leisure. Over the past century the customary hours of work have been reduced from 80–90 hours per week to scarcely 40, which gives us untold opportunities for rest, relaxation, and self-improvement.

We are a generous people. Voluntarily and freely we give of our substance to take care of those less fortunate than ourselves. In addition to caring for our own we have in the Marshall Plan made a gift without precedent in the world's history to rehabilitate the war-torn countries of Europe.

Can there be any better proof that the enlightened self-interest of a free people is a force without limit? Can any of us with experience in scientific fields be willing to set aside the results of so successful an experiment in favor of untried hypotheses? What possible further demonstration need there be that a free people can accomplish successfully any task to which they set themselves, whatever that task and however difficult?

Certainly we have not achieved perfection. But I submit that any lack of perfection is due not to the system by which we live but to the human frailties to which we are all subject. We learn by experience. We progress slowly but surely toward a more perfect life.

That problem is perhaps spiritual rather than temporal. But, whichever it is, we cannot be *forced* to perfection. Even Christianity has progressed only by persuasion, by education. In those misguided periods in which the church elected to use compulsion to secure spiritual betterment, Christianity stood still.

Criticisms of Present System

The great criticism that has been leveled at our system is that it runs in cycles from boom to bust. It seems to me that the explanation is not hard to find. We are today far beyond a subsistence economy. Perhaps not more than 60% of our productive effort goes to produce the basic needs of food, clothing, and shelter. The balance goes to what might be called "deferable" items —such as automobiles, radios, refrigerators.

Of course we want these things, but we can equally well do without them if we feel for any reason that the expenditure is not prudent. The war has taught us that we can, if need be, do without a new automobile every three years; that we can defer without serious damage the purchase of a new refrigerator; that we can wait another six months before buying that new television set. That large percentage of deferable items in our productive output makes us particularly vulnerable to mass psychology, for it is impossible to control what 140 million people will think and what they will do to implement that thinking. Clearly

mass thinking can bring repercussions to our economy and clearly it has done so in the past.

I suppose 1932 and the years immediately before and after were the worst depression this country has seen in several generations, but it was bad in a comparative, not an absolute, sense. There was no starvation—an annual occurrence in many less-fortunate countries. We suffered, it is true, but our standard of living in those troublesome years was better than the normal standard in many other nations.

I do not intend to defend booms and busts. It would be much more pleasant if we could progress uniformly and evenly without faltering on the way. But I should like to emphasize that those cycles which everyone deplores are only kinks in a curve of accomplishment that goes steadily upward, and it would be a poor solution indeed if by government mandate we were to smooth out the kinks only to find that our line of progress stopped rising.

Necessity For Large-Scale Enterprise

A second criticism of our system is that it appears to lead to large enterprises and substantial concentrations of economic power. Our company has been subjected to much belaboring on that thesis, and the idea that bigness is inherently bad is being widely advertised. That thesis seems to me to be completely fallacious. We have built up over the years a complex economy, and in fulfilling the material needs of our people there must be large enterprises doing the things that require great aggregations of talent and capital.

Automobile manufacture must be done on a vast scale if its products are to be made available at costs within the reach of many. Our company risked 43 million dollars in the foundation of a dyestuffs industry before profits offset losses. We had invested some 20 millions of dollars in nylon before a pound was sold from our first commercial unit.

Many similar examples could be given, not the least of which is the contribution of big business in the last war. Certainly it would be against the public interest to sacrifice these beneficial developments to the idea that there is in some way an inverse relationship between size and virtue.

Big business cannot stand alone. It requires, if it is to be successful, the cooperation of thousands of small businesses in the distribution of its products and in the provision of its raw materials.

The du Pont Company manufactures nylon yarn. It receives 10¢ for the nylon used in making a pair of stockings. Yet your wives will pay $1.25 for them in their retail stores. The difference represents the value added by untold numbers of small enterprises fulfilling their special function in the long chain that leads from raw material to the ultimate consumer. The du Pont Company cannot live without small businesses nor can *they* live without the du Pont Company.

We are part of a cooperative venture between large and small to secure the greatest benefit for everyone. Bigness is good if large businesses direct their efforts to the difficult accomplishments that only enterprises with large resources can attempt. If they grow simply for the sake of growing, inefficiencies are certain to arise which will become apparent in costs and prices. Under those circumstances the customers, who in the aggregate are the court of last resort, will effectively enforce any "sentence" that seems to them appropriate.

Let me summarize. We have in this country given free rein to enlightened self-interest through the doctrine of individual freedom. That enlightened self-interest has produced material things for all of us in greater abundance than the world has ever seen. We are the envy of the civilized world and, being strong, are subject to the petty carpings that surround anyone of great stature.

Freedom has its imperfections but they are the imperfections that arise from the human failings to which we are all subject and can be cured only as human

beings progress spiritually and naturally to a greater thoughtfulness for their neighbors.

But in that forward movement we must jealously protect the individual liberty which is the essence of progress, and resist any attempt at coercion and regimentation, whether that attempt be made by business—by labor—or, most important of all—by government.

Drifting Perilously Close to "Isms"

I have said before that we are in great danger of losing our birthright of freedom. We are making steady progress toward that degraded condition that has been variously called "statism," "socialism," and "communism." We have seen the plunge taken completely by Russia, where the individual is nothing and the state everything. We have seen England lose her position as a great nation because her people have allowed a misguided government to remove the individual incentive that is the only path to advancement.

We are taking the same journey and will reach the same end unless we are courageous enough to reaffirm those principles of self-determination that motivated our forefathers.

It is proposed that we embark on a program in which health is guaranteed, in which education is guaranteed, in which housing is guaranteed, and in which even charity is to be guaranteed. And who is to meet these guarantees? Clearly it is not a government that has no resources that do not come from its people. Clearly it is not the wealthy whose income is already virtually confiscated. It is simply the rank and file of us who are agreeing to a wasting of our substance to meet ends over which we have no control or, in the alternative, to foist upon our children bills that we incur in the full knowledge that we will never be able to pay them.

We are proposing also to guarantee to our farming population a fixed income, irrespective of what the rest of us may earn, to subsidize indefinitely a high price for the food that is the most essential element in our living.

The cost of these things is already staggering. In England, 40% of the country's income is channeled through government; here the figure is 25% and must go ever higher if the programs now being sponsored become effective.

Through these guarantees of security we are robbing ourselves in two ways: from the recipient of our enforced charity, we are removing incentive to take care of himself; from the donor, we are removing incentive because the load that he carries is so heavy that it becomes fruitless for him to attempt to better his condition.

We have already before us examples of the price we pay for these guarantees. For those individuals with annual incomes above $10,000, taxes have become so onerous as to prevent much saving, and for those individuals with income above $50,000 a year they have become practically confiscatory. Yet it is these very individuals whose thrift has produced the risk capital that has in turn provided the tools out of which our material progress comes.

Venture Spirit is Vanishing

The lack of venture capital is one of the most serious manifestations of the day. Industry has projects for the construction of new facilities requiring untold billions which would produce jobs, minimize the danger of unemployment, and add materially to our living standards. And yet it appears to be virtually impossible to secure venture capital for those expansions.

In 1948, only 10% of new corporate financing was made available through common stocks. Apparently the incentive to venture is disappearing, and industry is becoming less and less able to secure the funds with which to add to its productive facilities. There can be one result of those lost incentives and that is a decrease in our living standards and a weakening of our industrial sinews.

I have said that our theories of taxation are leveled primarily at the wealthy, as if indeed there were some evil social consequence to becoming rich. I think history has shown that that is not the case. There has been no personal fortune in America which has not had an enormous leverage in advancing the condition of thousands of people.

Henry Ford was, I suppose, one of the richest men in the world, and yet his personal fortune is inconsequential when compared with the uncounted benefits his company has produced for hundreds of thousands of people.

To take an example a little closer to my own experience: Much has been made of the wealth of the members of the du Pont family. Yet their wealth is as nothing to the benefits to the country of the thousands of jobs created over the company's one hundred and fifty successful years—to the billions of dollars of goods and services it has poured into the economy—to the opportunities that have come to thousands of small enterprises through its new developments.

Should we not reaffirm the principle that no limit should be imposed upon the heights to which man can reach—not because we love him but because we know that his effort cannot fail to produce for the economy and for us far more than it produces for him?

So let me return to my subject—"The Factors that Influence Industrial Activity." There is really only one basic factor—that is the freedom of the individual—the enlightened self-interest that permits any man to rise to whatever heights his abilities permit, to retain for himself the fruits of that rising, and, in so doing, to advance the common good.

This is not a very comfortable doctrine. It has only one virtue—that it is founded upon reality. It is fine to dream of a better world, and if we back up our dreams with hard work, they often come true. But they do not come true by themselves. We don't get anything just because it would be pleasant—or even essential—to have it. We get it because we produce enough so we can have it.

The responsibility that rests upon you gentlemen as educators is a great one, for you shape the men who will shape the future. I beg of you that you impress upon those men one thing: there is no security that we do not earn—that in this world nothing can be guaranteed—and that we advance, individually and collectively, by the sweat of our brows and the vigor, courage, and venturesomeness of our efforts.

College Notes

The retirement of Homer L. Dodge as President of **Norwich University**, effective February 1, 1950, has been announced. Dr. Dodge, formerly Dean of the Graduate College and Chairman of the Physics Department at the University of Oklahoma, will become President Emeritus. He will also be Director of the Cabot Fund activities. These will include the planning and construction of a new science building and the establishment of a program in Air Transportation.

The largest wind tunnel at any university for research on problems of high-speed flight was dedicated at ceremonies marking completion of the Naval Supersonic Laboratory at the **Massachusetts Institute of Technology.** Constructed under the auspices of the Navy Bureau of Ordnance, the wind tunnel was successfully operated this morning at a speed twice that of sound. The tunnel is designed to provide speeds ranging from 1.2 to 4 times that of sound—up to 3000 miles per hour.

Engineering and Technological Education in Great Britain, 1929 to 1949*

By W. R. WOOLRICH

Dean of Engineering, The University of Texas †

The most objective historical review of engineering and technological education in Great Britain is included in the first volume of Engineering Education, the two volume "Report of the Investigation of Engineering Education—1923–29" published in 1930 by the Society for the Promotion of Engineering Education prepared mostly by the late Dr. W. E. Wickenden, and Dean H. P. Hammond. It is generally identified in Great Britain as the Wickenden Report since the section on "Comparative Study of Engineering Education in the United States and in Europe" was prepared by him.

Within the past four years in Great Britain, there has been issued a report of a committee of which Lord Eustace Percy was chairman on "Higher Technological Education—1945," a second report of a committee of which Sir Allen Barlow was chairman on "Scientific Manpower—1946," and in 1948 the Advisory Council on Scientific Policy of the Lord President under the Chairmanship of Sir Henry Tizard issued their "First Annual Report on Scientific Policy." These are usually referred to in Great Britain as the Percy, Barlow and Tizard reports, respectively. Each emphasizes the importance of a great increase in the provision of scientists and professional engineers of very high educational attainments. While there is evidence in some of these reports of a somewhat jealous defense of either the University or the Technical College systems of British engineering education, the overall content of each is most constructive, frank and impartial.

Enrollments and Faculty Status

The enrollment in the Universities in engineering and technology which included also Architecture, Mining, Metallurgy and Applied Chemistry from 1938–39 to 1947–48 nearly doubled. This was the goal recommended in the Barlow Report. Five thousand one hundred and ninety-nine (5,199) men and eighty-nine (89) women were enrolled as full-time students in these several curricula in 1938–39. By the first of the school year 1947–48 the number had risen to nine thousand eight hundred and fifty (9,850) men and two hundred ninety-three (293) women or a total of ten thousand one hundred and forty-three (10,143), a 95% increase in nine years. The total increase in Wales was from one hundred eighty-three (183) to four hundred ninety-nine (499), or 172%; in Scotland from eight hundred and eighty-eight (888) to two thousand four hundred and sixty (2,460) or 177% and in England from four thousand two hundred and seventeen (4,217) to seven thousand one hundred eighty-four (7,184) or 68%.

The ratio of staff to student in universities in 1934–35 with Oxford and Cambridge excepted was 1:11; in 1938–39 it had improved to 1:10 and a vigorous

* Presented at a General Session at the A.S.E.E. Annual Meeting, Troy, N. Y., June 23, 1949.

† Served as Principal, then Chief Scientific Officer—U. S. Embassy, London, April, 1948–April, 1949.

effort is being exerted to maintain the one to ten ratio. When we reflect that the report in the "Higher Education for Democracy (Vol. IV, 1947)" stated that more than half of the institutions of higher learning in the United States have more than twelve students per teacher, the British practice must be considered good.

The salary scale for full time teachers and staff on the higher levels is not so far below those of the United States. There are, however, fewer men and women of full professorial stature per student in most Universities and much of the load of teaching is carried by faculty members classified as Lecturers who are generally in the five hundred to seven hundred pounds sterling group—a present day American equivalent of fourteen hundred to two thousand dollars. The 1947 report on University Development * estimated that currently fifty per cent of the faculties are under 35 years of age.

Often the justification for these lower salaries for lecturers is given as the "lower cost of living in Great Britain." Those of us who have lived in Great Britain recently cannot help but challenge this assumption as being quite mythical. The prices of items of living that are rationed and supported by Government subsidy are much less than in North America, but a large list of necessities of a family living in a university community are much more expensive than in the United States. Many very desirable items of personal equipment of a university teacher are prohibitively high in price. It would probably be more correct to claim that austere living in Great Britain costs less than ordinary living in the U. S. A.

The practice is very general over all of Great Britain to have only one professor in a department and he is the final authority in most matters related to that department. The Deans are usually elected by the faculty concerned and their responsibility is largely that of coordination of the several departments of the faculty with very limited administrative authority in relation to the professors represented within the Faculty. The British titles that correspond to the Associate Professor within North America are either Readers, Assistant Professors, or Special Lecturers. The Assistant Professor title of a university faculty member in the United States has its counterpart in the Lecturer of the British Universities while Assistant Lecturers and Demonstrators correspond to the Instructor level.

The title "Professor" carries much weight. It is noteworthy that in most all official correspondence and in official introductions the title *Professor* seems to take precedence over the knighthood Sir, the elected administrativeship Dean, and the prefix Dr.

The Rise and Scope of British Engineering Education

In the field of military engineering the British School of Naval Architecture established by the Admiralty at Portsmouth in 1811 and the United States Military Academy of West Point of approximately the same date appear to be the first military engineering schools to be established.

In the technical college field Andersons' College, later the Royal Technical College of Glasgow, established in 1796, appears to be the first school founded for the mechanics art. Birkbeck College, London, established in 1823, was founded to give education to students "in the various branches of science and useful knowledge" but apparently never gave any work that could be classed as engineering instruction.

University College, London, appointed a professor of engineering in 1828 but his election was opposed by the professor of physics and he never served. The Chair of Civil Engineering was established finally in 1941 at that institution.

Of the British universities, the record shows that Kings College, London, organized and instituted the first formal

* University Development 1935–1947, His Majesty's Stationery Office, London.

engineering curriculum in "Civil Engineering and Mining," October, 1938.* Thus Rensselaer Polytechnic Institute pre-dates the oldest British Engineering College by fourteen years.

The universities of the industrial areas of England from Bristol on the west to Leeds and Newcastle on the east portray a very well-integrated type of modern scientific engineering education and practice. In many cases they have a deep-rooted tie to practical technology by an affiliation with a higher technical college or with associated diploma level departments. This especially holds true at Bristol, Manchester, Sheffield, London and Leeds.

The degrees conferred for the engineering baccalaureate grade are not uniform. At both Cambridge and Oxford the Faculties of Arts are not subdivided, and the B.A. is the first degree obtainable whether the course leading to it is literary, engineering, or pure science. At Oxford the B.Sc. is awarded for special advanced study and research beyond the B.A., but at Cambridge the M.Sc. is conferred for such advanced work, the B.Sc. not existing there for any type of work.

At Liverpool and Sheffield the successful candidate for the first degree in engineering receives a B.Eng., while most of the other British universities confer the B.Sc., B.Sc. (Eng.).

Manchester College of Technology confers a B.Sc.Tech. for its baccalaureate degree in engineering under the authority of Manchester University. The companion courses in engineering, given by the University, lead, however, to a Bachelor of Science degree.

In metallurgy the general practice of British universities is to award the B.Sc. for the first degree. Liverpool, however, awards the B.Eng., Sheffield the B.Met., and Manchester College of Technology the B.Sc.Tech.

In mining likewise the general practice is to award a B.Sc. for the first degree, the exceptions being Sheffield, which confers a B.Eng., and Manchester College of Technology, which confers a B.Sc.Tech.

Quality of Students and Graduates

Due primarily to the excellent opportunity afforded British universities and colleges of technology to select the top few of students applying for admission from the many who qualify by passing the Higher School examinations, the students who receive their honours bachelors degrees in engineering in Great Britain are probably superior in basic scientific education to those of similar universities and colleges of the United States.

But at this level the superiority of the British engineering student ceases. This is the opinion not only of the writer, but is voiced by several British engineers interviewed by him. Further, as was previously indicated it is a published estimation by a very responsible committee of Great Britain as given in one of their current reports.

To give some appreciation of the time British engineering students spend in the classrooms to obtain their degrees the Percy Report of 1945 offers the following information:

"There are in England and Wales, eleven universities and two independent University Colleges in receipt of grants from the University Grants Committee, which provide degree courses in Engineering. Of these, the University of Wales comprises three, and the University of London four, distinct colleges providing such courses. In addition, students of four of the London Technical Colleges, and of the Sunderland Technical College, take the internal degrees of the Universities of London, and Durham, respectively; and the Manchester College of Technology provides the Faculty of Technology of Manchester University. The length of a first degree course at these institutions is ordinarily three years; and the period of full-time attendance required in each year varies from 24 weeks at Oxford and Cambridge to 30 weeks or more in the other universities. Students of Engineering usually take also a period of works training during the summer vacations."

* Bulletin: Kings College (London) Engineering Society, 1847–1947 by Prof. J. Davies, Dean of the Faculty of Engineering.

The three years mentioned in the Percy Report is for the Pass or Ordinary Degree. Many honors degrees require an additional year of attendance, much of which is devoted to research. But when we compare the twenty-four weeks at Cambridge with the thirty-four to thirty-six commonly found in the North American Universities, it gives cause for certain questions and doubts. The three years degree can be explained in that the preparation for the Higher School Examinations usually demands further study fully equivalent to one academic year of Junior College work in the United States. A large number of applicants for admission to the Universities have obtained their Higher School Certificate prior to submitting their applications.

Of engineering laboratory equipment only a few universities have an adequate supply according to American standards. A number of universities have fared well in obtaining surplus equipment after World War II, partly of English, and the remainder mostly of German manufacture. When ample building space is made available some of the institutions will be well equipped, but space and equipment to meet the increased attendance is currently taxing most institutions.

Turning now to advanced graduate studies, those who take further academic work for additional degrees must pursue little or no additional classroom lecture course work in most of the leading universities, but may confine their activities to research studies and conferences with their major professor. Some advanced students complained to the writer that even the title and nature of the thesis study was selected for them and the assigned research study was of particular interest to the professor but not to them except in that it provided a path to the desired degree. This, from the standpoint of inspiring creativeness, is liable to be most deadening since it imposes upon the student the thinking of yesterday rather than the scientific possibilities of tomorrow. It tends to encourage followership instead of leadership. But our United States educational procedure is not free from this practice, either.

There is no uniformity of policy in the conferring of the Doctor of Philosophy and the Doctor of Science degrees in British universities. In the English area the Doctor of Philosophy usually requires two years academic research beyond the Honours Bachelor Degree. The 1948 Universities Yearbook published by the Association of Universities of the British Commonwealth states: "All the Universities of the United Kingdom now confer the degree of Philosophiae Doctor. Candidates entering upon a course of advanced study and research for the Ph.D. must be at least 21 (Birmingham, Bristol, Cambridge, Durham, Liverpool, Oxford, Sheffield, Wales, Reading, St. Andrews, Dublin—no minimum age); must ordinarily be graduates either of the University or of some other approved University; must have pursued their studies at a University or Universities for a period of at least 3 years (Durham—2); must produce evidence of fitness for the proposed course of study and research. The course extends over two years at most Universities; and at Cambridge, Liverpool, Reading, Sheffield, Aberdeen, Glasgow, St. Andrews and N. U. I., the prescribed course of study is 3 years, which may under certain conditions be reduced to 2 years. Candidates on completion of research must present thesis and submit to oral examination on thesis. The degree is granted in any faculty in which the University is prepared to receive advanced students."

The Doctor of Science in the English universities is most often a professional degree conferred after five to seven years of practical experience, of which a part must have been in responsible charge of engineering work. A thesis or published work is submitted to the Graduate School authorities as a symbol of the character of the work the individual is capable of producing.

At least one institution publishes the statement that the Ph.D. of their university is above the M.Sc. but below the

D.Sc. as conferred by their faculty. The Ph.D. in engineering as conferred in the British universities is in no way comparable to the Ph.D. conferred by most member institutions of the American Association of Universities for advanced engineering study.

The Doctor of Philosophy is offered in most Scottish universities for a minimum residence study of two years beyond the Bachelors Degree and this minimum period is approved only after a graduate student has proven himself after three terms of graduate residence. The less talented applicants are advised to continue their work for three years beyond the baccalaureate degree. The Scottish universities do not offer Masters work in engineering.

Most of the Scottish universities offer a Doctor of Science beyond the Bachelor of Science degree with Honours, and this advanced degree may be requested only after five years beyond receipt of such honours degree. It is possible, however, to include six terms of academic work as a part of the five-year requirement. Whether the degree is conferred with or without further academic class work beyond the honours degree or not, a published thesis of the original research or an equivalent published work is required and, further, the applicant must have demonstrated outstanding achievement in his field of study in the engineering sciences.

Cultural Values Within British Universities and Technical Colleges

In the British Isles the title "university" can be applied to an institution only when they have Parliamentary authority to be so named and this recognition must come through the instrumentality of the University Grants Committee.

The name University or University College once authorized by the University Grants Committee implies parliamentary authorization to receive not only grants for the maintenance and operation of the institution, but further, that they might look to the University Grants Committee for much of the needed funds to build and equip the necessary additions to their institution in future years.

Historically the universities are empowered to grant the Bachelor of Arts, Bachelor of Science and then subsequent degrees as are based on higher attainment beyond these two forms of bacalaureate recognition.

The term "College" on the other hand may be taken by any educational group that proposes to train and educate the citizenry from one common level—usually above the grammar school—to some higher academic or educational level.

Parenthetically the term University College connotes an institution that is associated with a university system but has not as yet obtained the authorization to be fully autonomous, and thus it does its work under the guiding directorship of an established university. It exists and receives support by authority of the University Grants Committee.

There is a belief on the part of many British professional engineers that the education within a university broadens the perspective of the student, and the product, while generally not as well equipped in practical matters as the student of a college of technology, does advance to greater professional engineering heights in the longer pull beyond graduation.

The observation of the writer is that most generally there is a lack of the humanistic stem courses in most university engineering curricula of Great Britain for students on the advanced levels. Further, only a very limited number of men with bachelors degrees pursue further higher education. Thus there does not exist as large a percentage of top-flight engineering personnel completing their advanced resident engineering studies annually in Great Britain as is common within the United States, and the few who do so, follow vertical lines of scientific research.

Technical Colleges in Great Britain

As has been explained the term Technical College, in Great Britain, covers a varied range of technological educational institutions. Fully 200 colleges might be catalogued under this classification. The curricula of these educational centers may at the lower end of the technological scale be closely related to basic trade school work, while at the upper end of the instructional level they may be superior to and more characteristic of basic engineering science and research than that of some of the engineering departments of the lesser British universities. A large number of the better equipped technical colleges are engaged in a class of instruction similar to that of the technical institutes of the United States.

The Technical College group includes:

a. Sandwich Curricula Plan colleges giving courses of instruction not unlike the cooperative engineering schools of the United States.

b. College of Technology affiliated with established universities and with their curricula intewoven with those of the University's scientific courses, yet giving a large amount of their instruction to students not matriculated for University grade work.

c. Municipal Technical Colleges with a wide range of offerings and which well demonstrate the Huxley ideal of "an educational ladder reaching from the gutter to the University."

d. National colleges provided for a certain industry or a section of an industry which are important to the national economy but which employ relatively few personnel at any one industrial center.

e. County colleges—attended part-time on a compulsory basis by young people under eighteen but not in full-time attendance at some educational institution.

f. Venture and Endowment colleges in which a wide variety of technical courses are offered to students who have special needs.

The products from these many types of technical colleges are the reservoir of supply of technicians and operating personnel of much of British industry. As was observed in the recent surveys of the United States, industry generally requires from three to seven men of this grade for every graduate of engineering science of the Bachelors or Masters level.

Quite generally, Great Britain's educational and industrial leaders look upon the American procedure of admitting hundreds of men into the university engineering colleges, many of whom can never make the grade, as extremely impractical, wasteful and costly.

Herein lies the possibility of a very interesting study in the education of the "non-commissioned officers of industry of the two nations." Great Britain admits the United States system of production far outstrips hers. Her leaders also emphasize that their university atmosphere does something to the man who works towards his bachelors degree that the college of technology with limited offerings and fellowship cannot provide.

Has the unplanned system of educating men in the United States to a technical institute level by giving them one to three years in a college of engineering of a university made a contribution to the lives of these men that outweighs the intensive study of specialized skills within a technical college or its American equivalent—the technical institute?

No nation has done a better job in the training and educating of its technicians than Great Britain. Yet she cannot match the performance of a nation who has been most unorthodox in its training of technicians. To secure the correct answer to this question will require a most intimate and profound study of well-selected groups of men from the two nations. What is good for the professional engineer might also be worthy of consideration for the technician that works down on the next level of scientific attainment.

Personnel Exchange

The greatly increased number of graduate students and faculty men of Great

Britain and the United States who will be exchanged under the authorizations of the Fulbright, the Smith-Mundt and other appropriations will have a great effect in the scientific and engineering fields of both nations. Great Britain has much to give in the basic sciences and our greatest contribution will probably be in advanced technology and engineering economics.

The class room, the examination and the philosophy of engineering education is of sufficient difference as between the two nations, that Registrars and Administrative personnel of the universities of the two nations will experience many misunderstandings during the present decade, until we understand each other's procedures of engineering education better.

The writer has prepared a more complete supplementary report to this paper which gives a brief analysis of the engineering curricula offered at each of the British Universities and their affiliated technological schools. This supplementary material is the result of a personal visit to each British university offering engineering work of a baccalaureate grade. It is available by addressing the Bureau of Engineering Research, The University of Texas, Austin, Texas.

In conclusion, may I emphasize that previous government supported exchanges, primarily with Latin American nations to the South, were primarily unilateral in the physical and chemical sciences and engineering. The more recently established government sponsored exchanges with Western Europe and Great Britain have a high potential of bilateral exchange of men and knowledge in the engineering sciences. It is hoped that this and other contributions of current information on engineering and technological education and research in Great Britain and Western Europe may aid in placing the engineering profession of the United States in a more favorable position alongside the social and fundamental physical science professions to assure a fair proportion of engineering scientists and technologists to be included in the selected exchange personnel as made possible by the several procedures available or under consideration by the interested Governments.

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AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1950 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(2 years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Signal Corps Research and Its Relationship to Educational Institutions[1]

By HAROLD A. ZAHL

Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

I am indeed happy and honored to appear before this group for a discussion of the relationship between the Signal Corps research program and educational institutions. In addition to a keen interest in the normal program of engineering education, there exists another common bond represented by almost 100 major contracts spread among 50 educational or non-profit institutions, which not only aid in the support of academic research but also serve as a medium for maintaining the numbers of graduate students at the currently high level. While such research is sponsored primarily for the purpose of strengthening our national defense, yet every effort is also made to cooperate in the time-honored tradition that the prime objective of academic research should be the unrestricted advancement of basic knowledge through creative research.

Internal Research Program

Research and engineering applications thereof are not new to the Signal Corps. Progressive technical programs relating to military photography and wire communication date back to the Civil War. The present U. S. Air Force was born of Signal Corps pioneering in aviation during World War I. Commercial broadcasting arose during the 1920's directly from extensive military research and developments precipitated by the preceding conflict. From combined Service effort in World War II—and with magnificent contributions from the greatest scientific organization in all history, the Office of Scientific Research and Development, of which many of you were a part—came modern television, radar, proximity fuzes and myriads of other electronic devices, some exclusively military and others now changing the structure of civilian life in the direction of better living.

Today the research and development center of your Signal Corps exists within three laboratories in the Fort Monmouth, N. J. area, with a personnel complement of 80 officers, 250 enlisted men and 2600 civilians. Out of the 2600 Civil Service employees, almost 1000 are classified as professional scientists or engineers; 250 as sub-professional; 700 as clerical; and 650 as ungraded. Within the highly guarded confines of these three laboratories, personnel are engaged in an extensive research and development program leading to the production of the best and most advanced equipments for which the Signal Corps is assigned responsibility within the Department of the Army and the National Military Establishment.

Research in Colleges and Industry

Great as this internal program is, another program far more expansive, is carried on through contracts with industry, educational institutions and research foundations. All this effort is combined and continually being integrated with

[1] Presented before the ECRC at the Annual Meeting of the ASEE, Troy, N. Y., June 20, 1949.

the Signal Corps' internal program into a single movement, leading toward improved military defense—with also the occasional by-product of items or knowledge which can be released for immediate civilian exploitation. It is that part of the overall program which deals with research under Signal Corps sponsorship being conducted by educational institutions on which I wish to place most emphasis this evening.

First, let us consider the general technical scope of our contractual research program. The area of this effort is determined by the categories of equipments for which the Signal Corps has full or partial responsibility within the Department of the Army or the National Military Establishment, such as radiological instruments; photographic developments; detection projects involving sound or electromagnetic waves; electron tubes; facsimile and television; telephone, telegraph and other wire systems; radio communications; data transmission; aids to navigation; countermeasures against radio and radar systems; production of power by generators, primary and secondary batteries, and thermopiles; meteorological equipments; electronic components such as crystals, resistors, condensers and numerous others.

Development programs on devices as indicated above proceed continuously on the basis of the existing art. However, as a part of the Army's long-range program, research is underway extending the frontiers of knowledge in the sciences related to the various equipment categories. In that program, much of the basic and applied research is being carried on by educational institutions. In part, it may also be thought of as research in the field of magnetism and electricity, electron ballistics, microwaves, circuitry, elementary particles and their interaction, particle accelerators, solid state, deterioration prevention, electro-chemistry, thermo-chemistry, polymers, mechanics, applied mathematics, computing devices, atmospheric physics, propagation, radiation and heat, accoustics, power generators, biophysics and other fundamental categories.

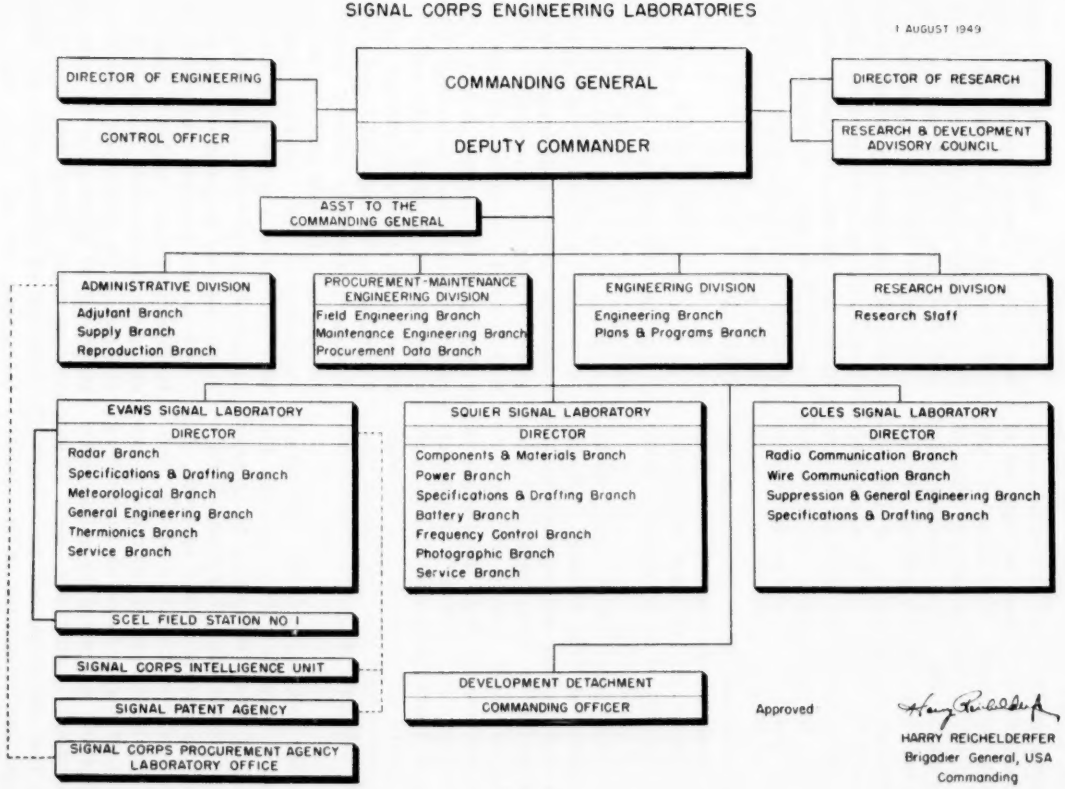
Unfortunately, it is not true that every educational institution desiring to do research under Signal Corps sponorship, need only apply and funds and equipments will be made available. We have severe limitations in budget to contend with—we have particular areas of interest which must be explored through applied research because of priorities based upon urgent military requirement, and for such, men with highly specialized training are sought—and of course, under the present conditions of international stress, the military must also remember that it may be imperative, should conflict come again, that certain academic laboratories possessing outstanding personnel and facilities for work in particular fields of direct military interest, may have to quickly expand many-fold. All of these items enter into planning a military contractual research program.

For truly basic research, the Army strongly favors a support mechanism such as is planned through the proposed National Science Foundation, since it is expected that only through such an organization can truly creative research receive the assistance it should have. Unfortunately, while such research is always important, it is never urgent, while applied research or development directed toward a military requirement often becomes urgent—and in comes the priority system! Basic research should more involve the support of creatively minded individuals than of projects, while for the most part, military research must involve a higher degree of organizational planning.

Contractual Relationships

Let us now depart from generalities and consider a few of the details involved in a university's contractual research relationship with the Signal Corps.

The Signal Corps offers to educational institutions a fixed-price contract which will contain a provision that all unex-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DEPUTY COMMANDER
DIRECTOR OF RESEARCH
RESEARCH & DEVELOPMENT ADVISORY COUNCIL
ASST TO THE COMMANDING GENERAL
ADMINISTRATIVE DIVISION
Adjutant Branch
Supply Branch
Reproduction Branch
PROCUREMENT-MAINTENANCE ENGINEERING DIVISION
Field Engineering Branch
Maintenance Engineering Branch
Procurement Data Branch
ENGINEERING DIVISION
Engineering Branch
Plans & Programs Branch
RESEARCH DIVISION
Research Staff
EVANS SIGNAL LABORATORY
DIRECTOR
Radar Branch
Specifications & Drafting Branch
Meteorological Branch
General Engineering Branch
Thermionics Branch
Service Branch
SQUIER SIGNAL LABORATORY
DIRECTOR
Components & Materials Branch
Power Branch
Specifications & Drafting Branch
Battery Branch
Frequency Control Branch
Photographic Branch
Service Branch
COLES SIGNAL LABORATORY
DIRECTOR
Radio Communication Branch
Wire Communication Branch
Suppression & General Engineering Branch
Specifications & Drafting Branch
SCEL FIELD STATION NO 1
SIGNAL CORPS INTELLIGENCE UNIT
SIGNAL PATENT AGENCY
SIGNAL CORPS PROCUREMENT AGENCY LABORATORY OFFICE
DEVELOPMENT DETACHMENT
COMMANDING OFFICER
Approved
HARRY REICHELDERFER
Brigadier General, USA
Commanding

FIG. 1.

pended funds be returned to the government. It is believed that this form of contract allows the institution the greatest degree of freedom in its operation of the contract and requires the least use of auditing personnel. This form of contract provides that a certain sum of money is available to the contractor which he spends in accordance with his ideas of the technical requirements of the contract, and the results of the expenditure of his funds are the property of the government. In most cases, contracts call only for quarterly reports on accomplishment. "Rights to publish" in scientific journals without prior government approval are generally granted in unclassified contracts. In all cases, publication and dissemination of unclassified information is encouraged.

Any such contract will contain an article known as "The Property Acquisition Article." This article provides that any materials or items purchased with government funds become the property of the government upon completion of the contract. In addition to direct purchases, if desired provision may be made in the contract for the loan of materials by the government which, of course, must be returned at the close of the contractual period.

Another point on property may be of interest to mention. This concerns the loaning of Army equipment to colleges and universities other than those directly performing research under contract. In specific instances the Chief of the Technical Service concerned may direct the issuance of major items of Department of the Army equipment on a loan basis to educational institutions, upon establishing that such a loan will serve directly to benefit the Department of the Army's research and development program. Such loans will be made only after such institutions have agreed to indemnify the Department for the reasonable value of property lost, damaged, or destroyed through willful misconduct, or failure to exercise good faith on the part of its officials, except that such liability will not extend to those supplies destroyed, expended or damaged in authorized research activity.

It may be of interest to indicate that the Signal Corps Research Property Officer at present has a record of seventy-three research and development contracts with forty-nine colleges and universities under which there is government—furnished or contractor-acquired property. There are four loan accounts with academic institutions not under contract. The value of such equipment provided academic institutions by the Signal Corps for their use in research now exceeds $15,000,000.

Patent Policies

The last 10 years have seen the development of an increasing patent-consciousness on the part of universities and educational institutions. A significant feature has also been the growth of separate foundations frequently affiliated with a nearby university and serving to exploit patents on their behalf. While some universities still will accept a sponsored project dealing only with basic research, an increasing number are participating in developmental and applied programs directed toward producing commercially feasible products or having applicability for military purposes. Whether this is for the good or bad, I hesitate to guess—my audience surely is better qualified to judge on this point.

The patent practices and policies of a large number of educational institutions are today incorporated in either the regulations of the institution, resolutions of the board of trustees, or in some other written form. There are other schools whose patent policies, while not reduced to writing, are still fairly well crystalized. Today, schools without any definite patent policies are very few indeed.

It is believed that the great majority of the universities hold and administer patents to produce income primarily for future research. A few universities are opposed to any patent-holding policy, in whole or in part.

CIVILIAN EMPLOYEES
SIGNAL CORPS ENGINEERING LABORATORIES
AT CLOSE OF FISCAL YEARS

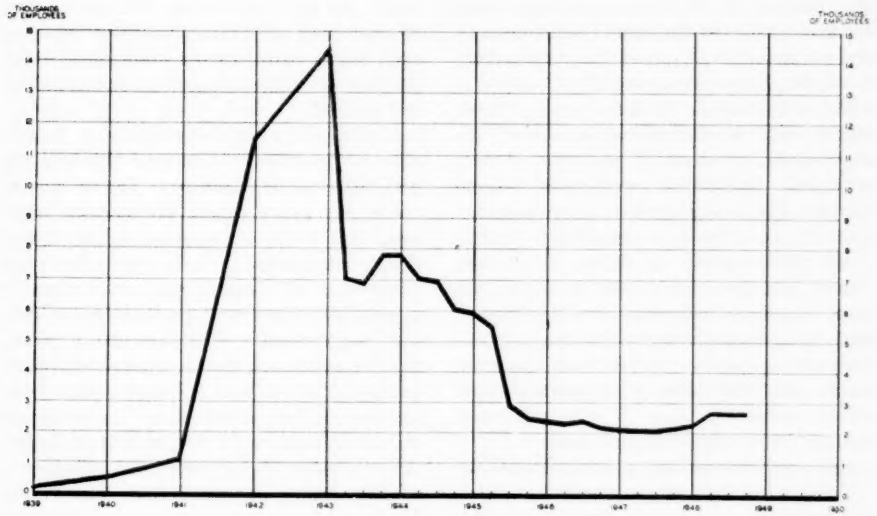

FIG. 2.

DISTRIBUTION OF SIGNAL CORPS RESEARCH EFFORT IN ACADEMIC INSTITUTIONS
SIGNAL CORPS ENGINEERING LABORATORIES
FORT MONMOUTH, NEW JERSEY

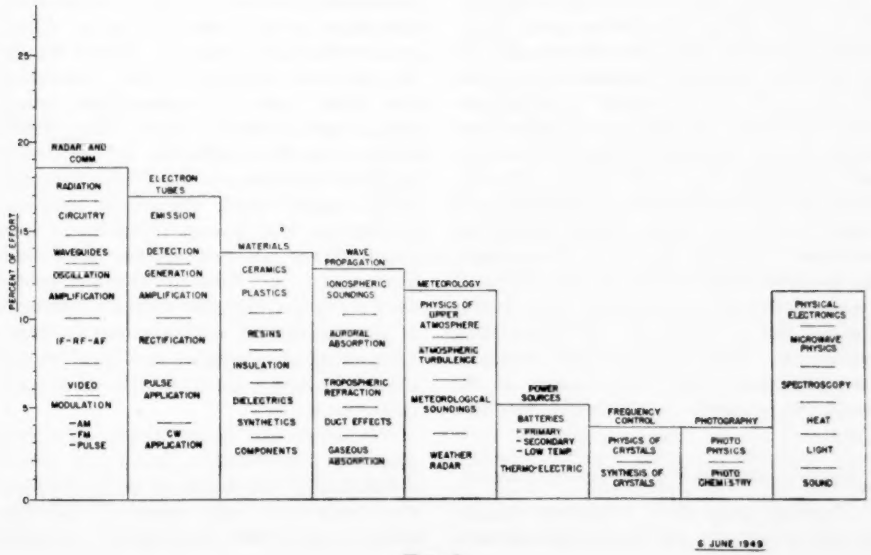

FIG. 3.

Since 1 November 1947, the effective date of current Joint Procurement Regulations under which the Departments of the Army and Air Force procure their research and development requirements, the government requires full title rights to all inventions resulting from contracts with educational institutions. These rights have been freely granted to the government in about 75 per cent of such contracts negotiated with the Signal Corps. However, where a proposed contractor has refused to grant the government title rights, deviation from this policy has been permitted in some unusual instances where it was determined that the particular university was uniquely qualified to perform the contract, and that the government would suffer irremedial loss if the proposed contract were not consummated.

As a general policy, patents owned by the United States Government are liberally licensed on a non-exclusive, royalty-free basis to anyone requesting the same for legitimate purposes. The government, of course, does not seek any profit by way of royalties on the patents which it owns.

It is of interest to note that during the past six years the Signal Patent Agency has administered the patent and copyright provisions of 106 research and development contracts between the Signal Corps and educational institutions. Approximately 80 per cent of these contracts were negotiated during the last two and one-half years. To date, 84 disclosures of inventions have resulted from these contracts. Since only about 30 of these contracts have been terminated, it is anticipated that several hundred more patentable inventions will evolve during the performance of the existing contracts—not to mention new contracts or extensions which will follow as the research program is continued into the future.

Opportunities in Civil Service Careers

Passing from such mundane matters as fiscal, supply and patent procedures, permit me now to elaborate a bit on matters relating to that all-important product of the academic world—your graduates! In this connection, I'm sure many of you have at times wondered why, or even been critical of the Civil Service for its lack of attractiveness to the graduating student.

Undoubtedly some criticism is justifiable. We have just passed through the greatest war in history. For a period there was grave doubt whether we could even win. We have retained our democratic institutions, but yet today the great bulk of Federal-sponsored research apparently must still be directed toward national defense. While we are at peace, great tension and fear remains. Primary justification for vast expenditures of the tax-payers funds, therefore, is not on the altruistic basis that research is desirable for the sake of advancing knowledge or raising our plane of living, but rather because of the grim realization that research will increase the security of the nation.

Many civilian scientists have difficulty in fully appreciating all the problems which pertain to the translation of research into weapons which when applied to modern warfare result in decisive action upon which victory hinges. There is a tendency to take the Armed Forces for granted without a full realization that there exist an intermediary scientific world without which the purely military or those who live in the highly rarified atmosphere of basic research could hardly work effectively together. I refer to that group of military men and civilians who are neither the Eisenhowers nor the Einsteins—but a group most essential for the military strength of the nation. It is this group to which most of your graduates will tend should they elect Army, Navy, or Air science for their career.

Gentlemen—in peace there are great scientific opportunities in such a career —but should war come again it would indeed require a high degree of clairvoyancy to guarantee a completely uninter-

rupted scientific research or development career. Permit me to illustrate with facts known to me through personal experience.

In 1931 the Signal Corps Laboratories staff numbered approximately 50, and the total yearly budget would not now sponsor one good-sized university research contract. We were at peace and government-sponsored research appeared unimportant, at least to those approving the budget.

Following December 7th, 1941, expansion of the Signal Corps Laboratories became so rapid that a peak of 14,500 civilian employees was reached late in 1942. Many of you will or have wondered just what an organization of that size with so many relatively unskilled personnel drawn so rapidly together could accomplish in a research and development program. But the exigencies of war produce strange requirements for a military research laboratory. There was first a vast multi-billion dollar procurement program, much of which had to immediately be placed underway without guiding specifications—production was based simply on models or sketches—and manufacturers required technical guidance—there were fantastic maintenance and supply problems involving hundreds of thousands of separately listed parts, including some for tropical or desert climates, some for the Arctic—there were the training problems for combat troops involving the adaptation of non-technical personnel to operate and service highly complex equipment—there were many of our permanent technical staff drawn into the uniformed Services because there too specialists were required—there were hundreds of "operational blitzes" requiring emergency-constructed equipments, and even operations, and so on. Yes, there was little time for research.

Experiences in World War II

War expansion of civilian groups was not too orderly. Order generally involves discipline, and discipline involves sacrifice of personal rights. Only men and women in uniform completely gave up their personal rights. Well I remember, in the months leading to and those immediately following the Pearl Harbor outrage, groups of 10, 20 or 30 new civilian appointees gathered under trees or temporary shelters receiving technical instruction from almost equally new personnel, pending assignment or completion of barn-type laboratories. The main scientific staff consisted of the permanent —the peacetime research and development cadre—but it was woefully small. There were many many special quasi-military scientific missions draining heavily upon the volunteer civilian scientist or engineer. Military personnel were only starting to receive technical training.

For example,—in July 1941, a few months before actual hostilities began, it was rumored that the Germans were planning a surprise invasion of Iceland. Radar installations were desperately needed, for continuous air patrol was unthinkable. SCR-270 and 268 early-warning radars were coming off the assembly line—some soldier personnel had received preliminary training, but the need for experienced engineers was vital, since early radar was hardly fool-proof. Word was received one morning that a ship was scheduled to leave New York at midnight with the first Signal Aircraft Warning Company, and it was anxiously queried—"could the Laboratories give immediate civilian engineering assistance to the expedition and also provide certain equipments?" Civilian engineer volunteers were recruited from the laboratory staff during the morning —they secured clothing and other personal essentials in the afternoon—early in the evening they scoured the laboratories, filling trucks with incidental gear needed to install an emergency laboratory and keep radar on the air. All rules of military supply accounting were completely abandoned in light of the emergency. That caused plenty of trouble later—but the men were ready,

equipped, and sailed at midnight. Iceland got its radar protection! Weeks later the civilian contingent came back to the Laboratories—not for research—not necessarily for development—but to whatever problem was next thrown back from the impending, and later the actual war front—and hundreds came!!!

Then came autumn of 1943. Production was increasing—but even more help was needed by industry to accelerate further. On the first day of September 1943, 4000 personnel with electronics training received in the laboratory were given separation notices by the Signal Corps Engineering Laboratories. Industry absorbed these people like water poured on dry sand. But the price the laboratory paid for this great service to production was tremendous. Organization confusion followed as during the earlier rapid expansion—almost like a hurricane—first the terrific winds of expansion, then a few quiescent months as the center passed, and then the reversal as the winds of contraction swept through!! Yes, gentlemen, life in a military laboratory during wartime has its vicissitudes, but so does life in a fox-hole! No wonder at times Civil Service was often criticized by those looking in through a small peep-hole! What system can possibly be perfect when operating under the duress of mortal conflict?

Educational Development

However, for almost three years now, forces of relative stabilization have been at work, even though world-wide tension remains. Serious attention can and is being given to organizational planning aimed toward establishing an ever-improving research and development environment. For example, to improve the formal educational background of our employees, arrangements have been made since 1947 with Rutgers University to maintain a branch of that institution at Fort Monmouth through which graduate credit is offered in the fields of electrical engineering and mathematics. Admission is governed solely by the Rutgers Graduate School Faculty. Classes in the graduate program are scheduled twice a week in the late afternoon. Thus the employee attends school half on government time and half on his own. Tuition charges to the student are also on the basis of one-half of the cost, the government providing the remainder in addition to the overhead administrative costs. Credits received in courses may be applied towards a Master's degree. Employees desiring to continue toward the Doctorate degree find it convenient to establish part-time academic relations with various nearby universities and at appropriate times are given a year or more leave of absence, without pay, following which they return to their original, or in most cases, an improved job assignment.

As a further step toward building up the scientific level of our employees, a recent announcement from the Civilian Personnel Division of the Department of the Army now makes it relatively simple temporarily to add to our research staff faculty members from accredited colleges and universities for periods not to exceed 130 working days per year providing such personnel have special scientific qualifications for the positions to which appointed. Through this procedure, it is hoped to interest outstanding academic research personnel to join the Signal Corps particularly during summer months and conduct research in areas of military interest using established facilities not readily available elsewhere.

Similar temporary employment may be given to graduate students for a period not to exceed one year provided the work performed is to be used by the student as a basis for completing certain academic requirements toward a graduate degree. And not to forget the undergraduates,—part-time or intermittent employment can be given to a number of such individuals for period not exceeding 130 working days per year and at compensations not exceeding $925 per annum.

All the above represent part of a pro-

gram to establish an environment which will draw a continuous supply of young scientists and engineers into the human framework necessary for a strong military laboratory—be it insurance for peace we hope—but ready for war if necessary.

Assignments for College Graduates

A few words now on the matter of permanent assignments to young personnel just leaving collegiate life will undoubtedly be of interest to this group. During the five major reductions in force experienced by our Laboratories, it was almost impossible to simultaneously consider any acquisition of young college graduates. Veterans of World War II were returning and competing for jobs held by World War I veterans, women, or by aged or crippled personnel not subjected to Selective Service—and by a few young men of outstanding technical qualifications who almost miraculously had been deferred from combat service. It was therefore not until the early months of 1948 that positive action could be taken to recruit and hire junior physicists, chemists and engineers. Reductions in force having ended and with work load steadily increasing, a modest increase in civilian allotments was received early in 1948, making it possible to set aside a small number of positions specifically for young engineering and science graduates whose previous experience was represented only in their bachelor's degree.

As a start, in January 1948, four junior engineers were employed by our Laboratories. They were the vanguard of young blood and represented only one-half of one per cent of the total professionals employed. By March 1949, the total rose to 84, which represents approximately nine per cent of the total professionals.

The junior engineer program is presently constituted along the lines of acquiring each year a group of young graduating personnel. Initially, these engineers will pass through a broad course of orientation and technical instruction so as to continuously bring out latent ability which will later assure proper assignment in the area for which the incumbent is most qualified and interested. The broad policy of the program provides for the assimilation of the junior engineers into the various professional fields in the scientific research and development work of our laboratories, correlating the capabilities, interests and aptitudes of each junior engineer with work underway. The original appointment probational period and ultimate regular assignment is conducted under competitive conditions, with close technical supervision and objective evaluation of performance. The policy provides both the Laboratories and the junior engineers with the opportunity to explore appropriate work assignments and eventual placement possibilities, furnishing an on-the-job training period which becomes graduate professional experience.

In actual practice the program operates in the following manner:

(1) A group of positions over and above operating authorization is provided to permit a hiring program independent of the irregularities in the rate at which vacancies by attrition occur. This group of positions is regarded as a reservoir providing a constant supply of technically educated young people for selection and assignment to regular professional positions.

(2) Hiring to these positions is done from permanent Civil Service registers of qualified junior engineers and scientists as developed by competitive examinations. Those so appointed are in probational status for one year.

(3) Following reception and interview, they are assigned to the organizational segment of the laboratories which is most fitting to the interest, and educational specialty of the new graduate.

(4) The immediate supervisor of the new employee is selected with as much

care as the appointee, in order to insure his receiving competent leadership, introducing him to proper techniques in research and development, and acquainting him with Signal Corps procedures.

(5) A comprehensive report on each junior engineer is required at the end of the first three months in probational status. This report is designed to be a candid evaluation of the employee's performance, attitudes, aptitudes, and professional bent; it is to be a consensus of the opinions of his supervisor, Branch Chief and Chief Engineer of the particular Laboratory, incorporating recommendations as to the desirability of assigning the junior engineer to a permanent position, reassigning him to another field, or terminating his employment.

Thus we hope systematically to acquire and assimilate the new graduate into our Laboratories. As he grows in experience he must choose between a completely technical career or one of compromising his technical ambitions with administrative responsibilities. In either case he has great opportunity, initially in doing and perhaps later in guiding others—be it in conducting research investigations into some unknown field in the physical sciences, or perhaps in developing or designing a minute electro-mechanical brain to be rocket-projected into the upper atmosphere to describe what it "sees" to curious mortals on earth; or it may be a giant radar set atuned to a celestial body or a man-made object coming over the horizon; or perhaps a system by which countless men can communicate with exchange of words, pictures or complex data during battle even though thousands of miles apart—all of these things and many others remain for the young graduate, should his desire be for scientific work in the field of national defense.

I hope that my remarks have given you more of an insight into our program, some of our difficulties, and the parts in which we have a strong mutual interest. The Signal Corps is deeply appreciative of the fine spirit of cooperation shown by the engineering colleges and universities in helping us in our research and in the ever-improved training your new graduates are showing as they join our Laboratories.

James H. McGraw Award

The James H. McGraw Award in Technical Institute Education will be presented for the first time at the Annual Meeting of the A.S.E.E. at the University of Washington. The Award will consist of an annual prize of $500 in cash and an appropriately engraved certificate. It is sponsored by the McGraw-Hill Book Company in memory of the founder of the company for the purpose of recognizing and encouraging outstanding contributions to technical institute education in the United States.

Dean Thorndike Saville, President of the A.S.E.E., has appointed the following Committee to select the recipient for the Award for 1950: E. E. Booher, J. T. Fiag, C. J. Freund, K. L. Holderman, L. V. Johnson, C. S. Jones, and H. P. Rodes, who will act as chairman of the committee. Ex-officio members are H. P. Adams and Dean Saville.

Nomination forms may be obtained from any member of the Committee or from Secretary A. B. Bronwell, Northwestern University, Evanston, Ill. Nominations may be made by any person or persons other than members of the Award Committee, or employees of the McGraw-Hill Book or Publishing Companies. Nomination must be mailed or delivered by March 15, 1950, to Chairman H. P. Rodes, James H. McGraw Award Committee, 130 Administration Building, University of California, Los Angeles 24, Calif.

Survey of College and Industrial Attitudes Toward Teaching Aids[1]

By GEORGE D. LOBINGIER

Manager of Student Recruitment, Westinghouse Electric Corporation

When the Committee on Teaching Aids started this year's work, it became apparent that an important part of the job would be to assemble basic data on the attitudes of engineering college staff members to using teaching aids in instruction, and on the willingness of industries to make available to engineering colleges teaching aid material of various types. No clear, up-to-date picture of the demand and supply was apparently at hand, even though the general subject of teaching aids had been discussed thoroughly and often. These basic data, it was felt, were necessary to determine whether further action would be justified toward establishment of a clearing house for teaching aid material, as proposed by Professor W. J. King at the Austin, Texas, A.S.E.E. meeting, 1948. This report is concerned with the results of a survey made to acquire these data.

It was decided to cover in the survey all deans of engineering and the heads of engineering departments in the accredited engineering schools of the country, with suggestions that all staff members of the engineering schools be given an opportunity to answer the questionnaires either on an individual or composite basis. In all, 1568 questionnaires were sent to college staff members. Essentially, the survey asked for expressions of interest in using fourteen different types of teaching aids, as classified by Professor King.[2]

The selection of the industries to receive the questionnaires was made on the basis of those companies employing engineers directly from the colleges upon graduations. Survey forms were sent to 407 industrial concerns, large and small, recruiting engineering graduates locally and nationally and they were asked to indicate which of the fourteen types were available for use by engineering colleges. Over 780 replies were received from the engineering staff members and 147 from the industries, a sampling of sufficient distribution to give weight, the Committee believes, to the basic data derived.

The Committee wants to thank each of those from the colleges and industries for his interest in replying. It was indeed gratifying to receive such response from another survey. Many letters accompanied the returned forms with valuable suggestions and comments, the great majority of which ranged from encouragement to enthusiasm for the individual items or for the project as a whole. Only a few were justly critical and none was antagonistic.

Results of Replies

Tabulations of replies are as follows. The column marked "College Staff" represents the number of affirmative replies

[1] Presented at the Teaching Aids Symposium at the Annual Meeting of the A.S.E.E., Troy, N. Y., June 20–24, 1949.

[2] "Industry-College Cooperation in Developing Teaching Aids," W. J. King, *Journal of Engineering Education*, October 1948, Vol. 39, No. 2, page 90.

	Wanted by College Staff	Available From Industries
1. Full-size models of machinery or apparatus.	300	18
2. Small scale models of heavy machinery, equipment and plants, either operable or static.	473	15
3. Cut-away sample or model of a particular device or component of some major equipment.	585	27
4. Small parts and mechanisms of standard commercial or production equipment.	424	21
5. Specially constructed laboratory apparatus for demonstrating some principle of science, or for research.	604	18
6. Special displays of unsolved or partially-solved design problems.	287	5
7. Industrial displays of the type commonly used in power shows, conventions, and expositions.	285	43
8. Charts, drawings, prints, photographs, or other pictorial displays of equipment, processes, and materials.	711	75
9. Charts and photographs depicting the organization and the activities or products		
10. Catalogs, instruction books, technical jour- of a particular company or industry.	317	43
nals, reprints, posters, house organs, and similar commercial literature.	600	100
11. Lantern slides of the 2-inch or 4-inch size, or 35 mm. strip film.	636	35
12. Sixteen mm. sound films of technical or industrial subjects.	673	64
13. Disc or wire recordings of talks by outstanding leaders of industry, science, and engineering.	250	10
14. Lectures or informal talks by engineers or by other representatives from industry.	534	64

of interest in using the type of teaching aid listed; in several cases, the replies were a composite opinion of entire departments. The "Industry" column represents the number of industries replying affirmatively on the availability of the appropriate device; in a few instances, the replies meant willingness to produce the teaching aids.

Availability of Teaching Aids

Obviously from the foregoing, there is some matching of demand and supply, but also considerable unbalance or disparity between interests and availability. A number of reasonable conclusions could be drawn from these data. It is apparent, for instance, that industry has leaned quite heavily on printed material, catalogs, technical publications, photos, drawings, charts, etc. (items 8 and 10) as its main contribution to teaching aids, and that these types have high preference among college staff members. No doubt the production of such material fits the purposes of commercial and informatory literature which industry has in its external customer or internal company affairs, as well as in its relations with colleges. Objections were raised in many comments accompanying the replies to the appropriateness of commercially slanted material as teaching aids. On the other hand, only a few companies produced

printed material or charts exclusively for engineering classroom use.

Films and slides (items 11 and 12) are both desired and available; general agreement existed on the value and willingness to furnish lecturers and speakers (item 14); neither colleges nor industries liked "canned" versions of talks (item 13). It is in items 1 to 7, models, parts, equipment, displays, etc., that the greatest unbalance occurs. Full-scale models and special problem displays (items 1 and 6) are not particularly desired by staff members, nor are they readily available from industries. Item 7, displays, is higher on the list of available aids, but is not particularly requested by colleges, largely because of space and storage factors, according to comments on the replies. Items 2 and 4, scale models and parts, are reasonably popular among colleges, but only available in a limited number of industries. Heavy preference exists for cut-away models and laboratory apparatus (items 3 and 5), but the number of industries having these is not large.

Although the great majority of comments acknowledged the values of producing and using teaching aids, there were a number of divergent viewpoints to be considered. Comments from both groups pointed out the limitations to various aids, such as questionable production expense, lack of space and facilities for proper use and display, and particularly the danger of over-emphasis. It is well to note that by general agreement college staffs want any supplementary materials or devices to be concerned with or illustrative of fundamentals. Many industries had little or no material to offer, either because the company had not the occasion to develop applicable aids or because the industry did not lend itself to production of suitable materials. Other companies preferred to handle requests from colleges on an individual basis, rather than by an organized plan of distribution. In some instances, the concerns frankly stated an interest only in supplying material to local institutions. A few large industries were skeptical of a clearing house for teaching aids because their own programs were sufficiently well organized to maintain desirable relationships with colleges. On the other hand, however, most companies and colleges agreed the idea of coordinating and interchanging information through a clearing house would provide better matching of supply and demand.

Conclusions

The net results of the survey, outside of consideration of specific types of teaching aids, warrant these conclusions:

1. There exists a great, but inadequately coordinated, interest among college staff members in using proper teaching aids to supplement regular instructional programs.

2. Industries, with only a few exceptions, are aware of this interest, but in the production of teaching aids have not had the full benefit of the guidance that adequate knowledge of interest in specific types would give.

3. College staff members have been handicapped in their use of teaching aids by the lack of knowledge of what is available.

4. Industry has expressed its complete willingness, within the limits of each individual company, to cooperate in supplying needed materials to the colleges.

5. It is reasonable to assume that a clearing house would be an effective means of coordinating the efforts of both colleges and industries in plans for supplying and using teaching aids.

Experiences with Junior College Transfers in Engineering[1]

By H. P. RODES

Assistant Professor of Engineering and Assistant Director of Relations with Schools, University of California

In a paper presented at the Austin Meeting of this Society in June, 1948,[2] Dean Thorndike Saville of New York University set the stage for our discussion today of junior college transfers to engineering colleges. At that time Dean Saville stated, "The establishment of many more community or junior colleges seems to be inevitable. . . . A trend already stimulated by the pressures of veterans' education will continue, and more and more both economic and intellectual factors will accentuate this trend. It will be possible to reduce the size of our freshman and sophomore classes (in engineering), where mortality has long been almost scandalous, and to provide better qualified upper class students."

It is apparent that Dean Saville's prognostication has become a reality in various sections of the nation. For obvious reasons, I shall attempt to discuss in some detail the situation in the State of California only, but I am aware of the fact that the trend toward wider acceptance of junior college graduates with advanced standing by colleges of engineering is gaining ground in many other states as well.

[1] Presented before a joint meeting of the Junior College and Technical Institute Divisions at the Annual Meeting, Troy, N. Y., June 23, 1949.

[2] "New Horizons in Engineering Education" by T. Saville, in *The Journal of Engineering Education*, Vol. 39, No. 7, pp. 344–354, March, 1949.

Growth of Junior Colleges in California

For the past few decades, the youth of California have been provided with the opportunity to obtain free public education through the 13th and 14th grades. In addition to the state colleges and state university, this opportunity has been made possible by the existence of public junior colleges located strategically throughout the State. In the Fall of 1948, these junior colleges, 50 in number, enrolled a total of 54,584 full-time students,[3] plus more than 125,000 part-time and evening students.[4]

In March of 1948, a Survey Committee, under the leadership of Professor George D. Strayer of Columbia University, submitted "A Report on the Needs of California in Higher Education." Included in this Report was a statement of the six specific purposes of a junior college, as formulated by the California Junior College Association and approved by the Strayer Committee. These objectives carried the following titles: 1. "Terminal Education"; 2. "General Education"; 3. "Orientation and Guidance"; 4. "Lower Division Training"; 5. "Adult

[3] *California Schools*, Vol. XX, No. 5, p. 124, May, 1949. Published by State Department of Education, Sacramento, California.

[4] Junior College Directory, 1949, p. 5. Published annually by American Association of Junior Colleges, Washington, D. C.

Education"; and 6. "Removal of Matriculation Deficiencies." [5]

The objective of primary concern in this discussion is No. 4, "Lower Division Training," which was defined in the Report as follows: "Each junior college should provide lower division or the first two years of senior college work for the limited number of students who plan transfer to a university after completing two years in junior college. This training should be broad enough to include the lower division requirements in the liberal arts, scientific, engineering and other professional fields." [6]

The University of California offers professional engineering training on three campuses—Berkeley, Davis, and Los Angeles. For many years the University has admitted qualified junior college graduates to full junior standing in engineering. Confronted with their share of the nationwide admissions problem during the past few years, the colleges of engineering of the University of California were forced to decide whether they would maintain a constant ratio of upper division to lower division enrollment, or whether they would expand the enrollment in the junior and senior years by entrusting to the junior colleges a larger share of the responsibility for freshman and sophomore training in engineering. On the basis of previous satisfactory experience with junior college graduates, it was decided to do the latter. Accordingly, by the Fall of 1948, enrollment statistics for the College of Engineering at Berkeley revealed the following pattern: Freshmen—267, Sophomores—435, Juniors—1128, Seniors—1009.[7] It will be noted that this pattern is quite the opposite of what was formerly considered a normal enrollment pattern. Instead of experiencing the usual decrease in enrollment after the freshman year due to failures and dropouts, these statistics show that 422% more students were enrolled in the junior year than in the freshman year. Stated differently, it is apparent that the great bulk of applications for admission to the College of Engineering are processed for enrollment in the junior year. This, of course, is due primarily to an increased dependence upon the junior colleges for providing the work of the freshman and sophomore years.

Freshman and Sophomore Preparation

Any college of engineering which shares the responsibility for engineering education in this fashion, however, can not expect to concentrate upon upper division and graduate study and give no further thought to lower division preparation. Increased reliance upon the junior college goes hand in hand with an increased obligation to share with the junior college the development of freshman and sophomore courses which will adequately prepare its students for transfer to the junior year in engineering.

The University of California is attempting to fulfill this obligation in a variety of ways:

1. For the past two years a Pre-Engineering Liaison Committee has been actively engaged in the crystallization and solution of many of the problems which confront the colleges that are preparing students for transfer to one of the University's colleges of engineering. The term "pre-engineering" is now generally accepted by educators throughout the State as including the freshman and sophomore years of engineering education. The Pre-Engineering Liaison Committee contains members who represent instructors and administrators from the junior colleges, private colleges, state colleges, State Department of Education

[5] Strayer, George D., et al., "A Report of a Survey of the Needs of California in Higher Education," pp. 5–6. (Submitted to the Liaison Committee of the Regents of the University of California and the State Department of Education, March 1, 1948.)

[6] *Ibid.*

[7] *Summary of Enrollment Statistics, October, 1948.* University of California, College of Engineering, Berkeley (Mimeographed).

and the University. The major activities of this Committee have included the following:

a. Comprehensive descriptions of lower division engineering and related courses are now being exchanged by colleges which offer the freshman and sophomore years of engineering training.
b. Appropriate summer session, extension and correspondence courses are being established for instructors of lower division engineering and related subjects. As an illustration, the University's Engineering Extension Division will offer a four weeks' Institute in Engineering Graphics during the 1950 summer session on the Los Angeles campus. This course will carry 4 units of credit and will combine the study of recent innovations in engineering graphics with teaching methods. Enrollment will be open to interested instructors throughout the country.
c. A Pre-Engineering News Bulletin is distributed from time to time as the need arises. In the past, this Bulletin has included such items as information about the entrance examinations required for admission to the College of Engineering, a reference list of timely publications of interest to engineering instructors and students, changes contemplated in course content and curricula at any of the engineering colleges, etc.
d. In the Fall of this year a one-day conference of pre-engineering instructors will be held in the northern and southern sections of the State. These conferences will be attended by instructors of lower division engineering, mathematics, chemistry, and physics courses from the colleges of engineering, as well as from the junior colleges and private colleges. The topics to be discussed at these conferences have been suggested by the instructors themselves on a questionnaire which was distributed to pre-engineering colleges throughout the State.
e. The Pre-Engineering Liaison Committee was able to initiate a change in the requirements for junior college teaching credentials which enable the graduates of engineering colleges to obtain such credentials with greater facility.
f. The location of the University's engineering entrance examination centers was revised to meet the needs of students in colleges in remote areas of the State.

Many other appropriate projects have been and are being undertaken by the Pre-Engineering Liaison Committee.

Admission Procedures

2. Secondly, the University of California is constantly refining its method of admission to the junior year in engineering. At present a battery of tests lasting one full day is required for all applicants for admission to the upper division courses in engineering, including those applicants who have completed their first two years of training at one of the University's Colleges of Engineering. These tests attempt to measure achievement in five subject fields—English, Mathematics, Physics, Chemistry and Engineering Drawing.

Prediction studies, recently completed for transfer students admitted to the junior year in engineering during 1947, revealed a correlation coefficient of +.630 between the total scores on these tests and subsequent grades in engineering courses. The correlation between grades in lower division engineering courses and subsequent grades in upper division courses was + .643. By combining previous grades in a two-to-one ratio with the total scores in the junior status engineering tests, a correlation coefficient of + .702 was obtained. This means that success in the upper division engineering curriculum can now be accurately pre-

dicted 76.7% of the time, or in better than three cases out of four.[8]

A study of the comparative performance of junior college transfers and native students on these tests indicated that there is no significant difference between the two groups. In other words, engineering students who have completed the first two years of study in a junior college do about as well on these tests as students who took their lower division training at the University of California.

It is apparent, therefore, that the junior colleges are able to perform a valuable service to the engineering colleges in the matter of student selection. The junior colleges recognize, however, that the use of reliable and valid examinations for admission to the junior year in engineering enables junior college counselors to implement the selection process more effectively.

Curricular Experimentation

3. The third way in which the University of California is attempting to share the responsibility for engineering education is by providing the junior colleges ample opportunity for experimentation with the lower division engineering curriculum. The changes which have taken place recently in the first two years of engineering instruction lead to the conclusion that a completely standardized lower division curriculum is neither possible nor desirable. Moreover, the intellectual stimulus provided by appropriate course experimentation is essential to the professional growth of administrative and faculty members alike. This is true to as great an extent in our junior colleges as it is in our professional schools of engineering. The engineering colleges which now share or intend to share the responsibility for lower division instruction with the junior colleges must permit and encourage appropriate experimentation, both within and without the common core of basic preparation in such subjects as mathematics, physical science, graphics and mensuration.

A recent survey of the course offerings of the California junior colleges revealed that all except a few of the smaller colleges are now offering lower division courses in engineering which parallel those offered by the University. Nevertheless, the University's colleges of engineering are actively encouraging the junior colleges to prepare students for upper division work in engineering in any way they see fit. This encouragement has been rendered effective in two ways —one, by avoiding any prescription of course content for admission to the junior year in engineering and, two, by adopting a liberal transfer policy which even permits the qualified graduates of a junior college terminal or technical institute type curriculum to enter the College of Engineering with advanced standing. Concerning the latter, the University's Board of Admissions has adopted the following statement of transfer policy, upon recommendation of the deans of the Colleges of Engineering:

"Students who wish to transfer to the College of Engineering from a technical institute or a junior college technical-terminal program will be expected to meet the existing University requirements for admission to the freshman year. In consultation with a faculty advisor, placement in engineering courses will be determined by the student's previous scholastic record and his performance on an appropriate aptitude or achievement test. After he has demonstrated his ability to do the work required with a satisfactory grade point average, the College of Engineering will evaluate his non-certificate terminal courses and recommend transfer credit for them to the extent that they are found to have served the student as preparation for his advanced work in engineering."[9]

[8] Moredock, H. S., "Prediction Studies," College of Engineering, University of California, Berkeley, 1949 (mimeographed).

[9] Minutes of the Board of Admissions and Relations with Schools, December 3, 1948, p. 7, University of California, Berkeley (mimeographed).

This policy has been used already and with apparent success. Several graduates of technical institute type curricula who indicated interest and ability in professional engineering have been admitted to the College of Engineering with advanced standing of anywhere from one to four semesters. The scholastic records of students thus admitted have not differed significantly from those of students admitted with the normal pattern of lower division engineering subject matter. Whenever the graduates of a technical institute type program provide valid evidence of being able to complete satisfactorily the upper division curriculum, it is difficult for an engineering school to justify arbitrary requirements of course content for admission with advanced standing.

Other Methods of Cooperation

4. Another indication of the University of California's method of sharing lower division instruction in engineering with the junior colleges is the frequency of mutual visits with representatives of both the junior colleges and the colleges of engineering. It is not uncommon for the deans of the engineering colleges to visit a junior college upon invitation to discuss with engineering instructors and counselors any specific transfer problems.

5. The recent appointment of a member of the College of Engineering faculty as Assistant Director of Relations with Schools has facilitated the communication and coordination between the junior colleges and the University. If this method of assigning responsibility for liaison activities continues to be mutually satisfactory, it might well be considered by other schools of engineering as a possible approach to the improvement of coordination with the junior colleges.

Although such devices as the five outlined above are important to any program of adequate cooperation between a school of engineering and the junior colleges, these techniques are valueless unless the administrative and instructional staffs of both types of institutions are sincerely desirous of developing a mutually satisfying arrangement. If key staff members of an engineering school are prejudiced against those students who have transferred from a junior college—or if the junior colleges recommend students of doubtful ability for transfer to a college of engineering, then any efforts to effect a satisfactory transfer procedure and undestanding are bound to end in failure. On the other hand, the experience of the past few years, and the situation in California is merely one example, has proved that a policy of mutual cooperation and understanding can result in a junior college transfer arrangement which is beneficial to the schools of engineering as well as to the contributing junior colleges.

Summary

By way of summary, the benefits which accrue to a college of engineering that participates in such an arrangement include the following:

1. By assisting and encouraging the junior colleges to provide freshman and sophomore instruction for most of its potential student body, a school of engineering can offer better instruction, both in quality and quantity, at the upper division and graduate levels.

2. The high rate of student mortality, for which engineering schools have long been notorious, can be decreased significantly by depending upon the junior colleges for the selection of upper division engineering students. Moreover, the student who formerly would have left a school of engineering with the unfortunate label of "failure" has an opportunity in the junior college to shift into one of the many technical institute or vocational curricula in which his technical interests and aptitudes might be successfully developed.

3. The greater attention which can be given to individual students in the junior college, plus the better opportunity to make up subject deficiencies, has salvaged

for the engineering profession a number of outstanding students who might have dropped by the wayside had they attempted to enter a school of engineering at the freshman level.

4. The high quality of conscientious instruction which takes place in many of our junior colleges has set a fine example for the instructors in our schools of engineering, some of whom have a tendency to treat the courses of the freshman and sophomore years as being of lesser importance than those of the upper division and graduate years.

5. Studies of relative performance have indicated that junior college graduates do just as well, both in the examinations for admission to the junior year and in the subjects of the junior and senior years, as do those students who have completed their lower division work in a college of engineering.

These five factors, plus many others of lesser importance, explain why approximately 60% of the engineering graduates at the University of California in June of this year completed their lower division work in engineering at a junior college. Although this percentage will probably be even higher within the next ten years,[10] it will not approach 100% due to the fact that it is considered imperative to retain a small pilot group of freshman and sophomore engineering students for two reasons—first, to permit further experimentation with the lower division engineering curriculum and, second, to avoid any possibility of having the instructors of upper division engineering courses exert pressure upon the junior colleges for an unreasonable increase in student achievement.

In conclusion, the experience of the University of California with junior college transfer students has been most satisfactory. Although the conditions which have made this possible include the existence of a statewide system of junior colleges, it is believed, nevertheless, that appropriate variations of the California plan could be employed to advantage by engineering schools and junior colleges in other areas. Moreover, to quote again from the Strayer Report on California's Needs in Higher Education, "If this plan can be followed in engineering, where there are many preparatory and prerequisite courses, it can also be followed in other fields." [11]

[10] "The University of California in the Next Ten Years," Proceedings of the University of California's Fourth All-University Faculty Conference, Davis Campus, April 28–30, 1949. Pg. 8, University of California Press, Berkeley, Calif.

[11] *Op. cit.*, p. 8.

Sections and Branches

The thirtieth annual meeting of the **Kansas-Nebraska Section** of the A.S.E.E. convened at a dinner meeting at the University of Kansas on November 11, 1949. L. Hollander presided and introduced the speaker of the evening, General M. S. Eddy, who spoke on the subject "Russia and the Atom Bomb." Mr. C. G. Roush, Sales Manager, Westinghouse Electric Corporation, Kansas City, Mo., spoke on "The Role of Industry and the College Educator in the Industry-College Relationship." This was followed by discussion from the floor. "Testing Program for Purposes of Guidance" was the title of a talk given by A. H. Turney, Director of Guidance Bureau, University of Kansas. A formal discussion was presented by M. D. Woolf and discussion from the floor followed.

The annual business meeting was held on November 12, 1949, and the following slate of officers for 1950 was unanimously elected: President, F. W. Norris; Vice President, W. Tripp; Secretary, A. S. Andes.

Economics as a Humanistic-Social Study

By ARTHUR STARTZ

Instructor in Humanities, Cooper Union

The elementary economics course has better chances for success in an engineering college than in an arts college, although teachers in economics, social science, and humanities departments of engineering schools sometimes tend to emphasize the limitations of engineering students in these fields. Often heard are statements by the faculty such as these: "they want to measure everything . . . if it can't be measured, they consider it unimportant . . . in their desire for accuracy and exactness, they lose sight of the forest for the trees . . . they want everything handed to them in outline form, already digested . . . the scientific method has become their God."

How is the economics instructor in an engineering school at an advantage over his counterpart in the liberal arts college?

1. In the engineering school it is not necessary that the study of economics be placed at the beginning of the curriculum as it is generally in the arts college. The third year is ideal. The students are more mature and have acquired background from other courses. The historical, philosophical, psychological, or legal background which the engineering student gets in an integrated humanities program is extremely valuable.

2. Upon reaching the junior or senior year, the engineering student has had the "scientific attitude" developed to a high degree. Although there is no automatic transfer of the scientific attitude from the physical to the social sciences, there is a much better basis upon which to build. In this connection, teaching in the economics course can be especially effective if the problem or institutional rather than the theoretical approach is emphasized.

3. Training in mathematics and allied fields places the student at an advantage in understanding mathematical concepts of the elementary economics course. He will have little trouble comprehending the meaning of graphic presentations. The instructor can present statistical data with the comforting feeling that the student will point out the meaning.

4. The instructor doesn't have to train students who may specialize in economics or allied social sciences and does not have to direct the course toward providing a background for such students. There are many economics teachers and texts attempting to delve into the highly complicated aspects of economic theory in the elementary course but these would do well to ask themselves what they are trying to accomplish.

Objectives of Economic Courses

What are the objectives of the economics courses in an integrated humanities program?

The foremost aim is that of citizenship. The very survival of democracy is dependent on a populace literate in economics. It is especially desirable that young men who will attain leading and respected positions have a high degree of economic literacy, that they have a comprehensive understanding of how our economy functions, what the important contemporary economic problems are, what solutions have been proposed, and how economic principles can be applied. The development of attitudes, emphasizing the necessity of an objective ap-

proach, is an important aim of the course.

The instructor should have no hesitancy in teaching the meaning of economic terminology which has achieved popular usage, being careful not to spend time on terms which are of use only to the professional economist. Memorization of factual data should be kept to a minimum. Students should learn of the outstanding sources of economic information and how to use them. They should become familiar with the basic philosophy underlying the work of outstanding economists but this does not mean that discussions should be of the ivory-tower type. A final aim of the course is to aid students in understanding and meeting some of the personal economic problems with which they will be confronted in later life.

The development of specialized techniques which may be useful to the engineer, e.g.: cost comparisons, specific accounting problems, statistical methods (correlation, etc.), can best be accomplished in a separate course in engineering economics. This does not mean that the elementary economics course will be of no help to the engineer in his job situation, but merely that problems of the type mentioned should be covered in a separate course.

As important as it is to set forth these generalized objectives, nothing will be accomplished unless the instructor sets forth two for himself. What are the specific aims of this particular session? What are the best methods to use at this session to accomplish these objectives?

Aids to Teaching Methodology

To answer the second question, that of methodology, the economics instructor is in an advantageous position, for all of the techniques of progressive education can profitably be employed. Although too seldom done, subject matter of the elementary course can be directly related to the student's personal experiences. Visual aids in the form of graphs and charts, large enough for the whole class to see, and brought up to date by the instructor, are extremely useful in stimulating interest, showing trends, and imparting specific knowledge of important statistical data. Newspaper and magazine articles, radio and television programs, and political speeches dealing with economics can be correlated with the specific phase of the subject scheduled for class discussion.

"Learning by doing" is a concept that can be profitably employed. Students will get a basic understanding of what index numbers are and some of the problems involved in their construction, if they construct their own to compare the plane of living of their families today with that before the war. Each will have a stake in seeing how his status compares with that of the group and with that of the nation, as evidenced by the Bureau of Labor Statistics Consumer Price Index and wage statistics. Surely this approach is better than to tell students that one of the best types of index numbers is one that is derived by taking the square root of the product of an arithmetic mean weighted by base year weights and a harmonic mean weighted by given year weights.

Although most of the branches of economics may remain the same as those in the traditional course, the approach and the emphasis on specific topics in each branch should be different. After an introductory discussion on the meaning of economic law, the use of the scientific method in economics, and how economics differs from the physical sciences, the instructor may well ask the class what the most important economic problems confronting us today are. The daily newspapers as well as personal problems will answer that question and most will agree that among the foremost principal issues of the day are these: world peace, inflation, labor-management relations, housing, economic insecurity, capitalism versus communism, growth of monopoly power, and high taxes. Daily newspapers and radio news reports are concerned with several or all of these prob-

lems. Here, then, is a basis for proceeding in the course. If the subject matter concerns itself with these problems, interest will be maintained, misconceptions will be cleared up, and students will be better able to take their places in this society which is crying for an intelligent approach to economic problems.

National and International Problems

In discussing international trade and world peace today, the European Recovery Plan would hold the spotlight. How does this tie in with the doctrine of comparative advantage? What is the present position of the United States in world trade? Has this position been changing? How is E.R.P. concerned with this changing position? How does this affect prospects for peace? These questions are far more important to young engineers, many of whom will take no further courses in economics, than a technical discussion on the methods of settling international obligations.

The discussion of the problem of inflation can be started with a presentation of the overall statistical picture of prices in the United States today. Students have little knowledge about this. Where do prices stand today as compared to before the recent war? How does this compare to the change in wages and profits? Has there been any significant change in these relationships during the last three years? How is the price level measured? How are index numbers to be interpreted? How are prices determined under conditions of competition, imperfect competition, monopoly, oligopoly? What does the equation of exchange have to do with the problem of inflation? How does the federal reserve system provide for mechanisms which attempt to control credit availability? Is price control the answer?

The importance of government in the labor-management relations field has increased tremendously in recent years. The Taft-Hartley Act is a burning issue of the day. Many students have intense feelings about the act with little knowledge of what it actually provides. What are the provisions and underlying philosophy of this law? How does this differ from the Wagner Act, to which unions want to return? How does this tie in with wage theories which have been proposed? What are the essential issues in the closed-shop, union-shop, open-shop controversy? How does the collective bargaining process work? What are the various methods for solving labor disputes and what are the merits of each?

The housing problem is a familiar subject to the students, many of whom are veterans. The subject may be introduced by a statistical presentation of the extent of the problem today. How is the law of supply and demand applicable? What proposals have been made to alleviate the shortage? Is private home building a solution? How is private home-ownership financed? Approximately how much do carrying charges amount to in the case of a low-priced home? Should the individual buy, build, or rent? What portion of one's income should be allocated for housing? Is public housing the answer?

The importance of the problem of economic insecurity is well known to this group which grew up during the last depression. What has government done to try to bring a greater degree of security to individuals? How does the philosophy of government interference fit in with the Malthusian doctrine? What are the provisions of the Social Security Act on unemployment insurance, old-age insurance, old-age pensions? What changes have recently been recommended? What do Workmen's Compensation laws provide? What can the individual do to attain greater economic security? What are the main types of life insurance, liability insurance, health insurance, accident insurance? What are the issues involved in the recent proposals for national health insurance?

There has been no attempt here to present a rigid or all-inclusive outline for the course. The type of approach appeals to the engineer. The problems

with which we are confronted are defined. We then seek to determine how economic principles can be applied in an effort to meet the problem. In so doing, we learn what the principles are. Only in this way does the study of economic principles or "laws" have meaning to the students. Although such a course requires more effort on the instructor's part than does the traditional course, the results will more than compensate for the additional work in terms of student participation, interest, and growth in meaningful citizenship.

Mechanics Division Summer School

Iowa State College, in cooperation with the Mechanics Division of A.S.E.E., is sponsoring a summer school for teachers of Engineering Mechanics. The theme of the school is "Dynamic Teaching of Engineering Mechanics" and the program will be organized to assist both the young instructor and the more mature teacher in presenting his subject matter effectively and efficiently. Techniques of presentation and critical analyses of course content will be emphasized. The discussions will be led by experienced teachers, and ample opportunity for participation will be afforded everyone attending.

The school will be held at Iowa State College from Monday, September 11, 1950 through Friday, September 15, 1950. Correspondence concerning the summer school should be addressed to Dr. Glenn Murphy, 101 T. & A. M. Laboratory, Iowa State College, Ames, Iowa.

Third Annual Exhibit of Teaching Aids

The extensive exhibit held at the 1949 annual meeting of the A.S.E.E. at Troy justified the conviction of the Subcommittee on Teaching Aids that considerable teaching aids material of excellent quality was available from engineering teachers but needed to be uncovered. Those who saw the 1949 exhibit are conscious of many new ideas and techniques exhibited at this meeting. It is hoped that the third annual exhibit can be even more extensive and stimulating.

Persons who have not previously exhibited any form of teaching aid or previous exhibitors who have additional material to show are encouraged to write to the chairman of the Subcommittee on Teaching Aids indicating their desire to exhibit at the 1950 meeting at Seattle. Ample space will be provided to exhibit any of the fourteen types of teaching aids discussed in the reports of the Subcommittee.* Details of when and to whom shipments of exhibit material should be made will be reported in a later issue of the JOURNAL, or such information may be obtained from the chairman of the committee. Equipment will be available with which to screen silent or sound motion pictures, slides or slide-films, wire or tape recordings, or any type of model or teaching aid. Self-explanatory exhibits will be set up and dismantled for return to the exhibitor. It is expected that operating models will be exhibited by individuals who will be at the meeting and who can be present during the exhibit hours. A most valuable adjunct to the actual exhibit at the past two annual meetings has been the interchange of information which has resulted from contact with other exhibitors and visitors.

Further information may be obtained from the committee chairman, Professor Carl W. Muhlenbruch, Department of Civil Engineering, Northwestern Technological Institute, Evanston, Illinois.

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* "Industry-College Cooperation in Developing Teaching Aids," JOURNAL OF ENGINEERING EDUCATION, October, 1948, Vol. 39–2, pp. 90–94.

Some Thoughts Concerning Surveying Instruction

By MILTON O. SCHMIDT

Assistant Professor of Civil Engineering, University of Illinois

There are many opinions today regarding the place of Surveying in the Civil Engineering curriculum. Considering that they are divergent opinions and that it is our task to resolve them in order that the most effective contribution can be made to Civil Engineering education, I would like to consider with you some of the elements of good surveying training in our professional engineering colleges.

There is first of all a need to arouse in the civil engineering student a greater degree of interest in the subject of Surveying and Mapping. It is not a decadent science or art although the execution of simple, unintegrated exercises on the campus accompanied by prosaic lectures will give the student this impression. Emphasize to your civils that surveying secures the factual data without which no major project of engineering construction would be feasible. Adequate maps are essential for efficiency and economy in private and public activities involving our natural resources. Point out that planning, whether it be national, state, or city planning, is primarily an engineering operation and complete and accurate survey and map information is necessary if present and future development is to be orderly and economical. Cite the notable flood control, navigation, irrigation, railroad, and highway projects that began with the precise transit and tape, the aerial photograph, and the current meter. Maintain a display of maps of all types. Large-scale, special-purpose maps of the United States Geological Survey and the Corps of Engineers are particularly worthwhile. Maps of the Tennessee Valley Authority, Air Navigation and Nautical Charts, and city maps like those of Pittsburgh will stimulate interest in topographic mapping and photogrammetry.

Establish High Standards

Second, I suggest that a concerted effort be made to maintain higher standards of accomplishment in our surveying courses. During the past ten years there has been a general tendency to emasculate the courses in surveying although the attrition is euphemistically termed streamlining. There is more need, therefore, for efficient instruction. In surveying as well as in other forms of engineering activity, the ability to produce is important. Hence, I suggest you teach surveying as a production activity. Assign plenty of field work and permit the student parties to advance as rapidly as possible. Have no more than two men in a party for most exercises. The practice of distributing complete instructions for field problems at the beginning of the semester and permitting the parties to work ahead as rapidly as possible has considerable merit. A weighted value, in per cent, can be assigned each problem and the progress of each party can be portrayed by a curve drawn on graph paper which is posted on a bulletin board. I think you will find that a friendly competitive spirit will be developed. Surveying is best taught by surveying. The more practice the student acquires the more competent he will become. A

minimum of instructional advice in the field, or perhaps even none, is best suited to develop thinking and judgment.

Third, I would like to emphasize the desire to avoid the pedantic approach. Avoid any idiosynerasies which will cause other than a favorable effect on the impressionable student. Don't split hairs and avoid vacillation. Be the practical-minded chief of party that your students would like to work for. Remember, surveying is practiced out in the work-a-day world, not on the cloistered campus.

Developments in the Art

Fourth, I would like to emphasize the need for the surveying instructor to be better informed of developments in the art and to impart to his students a general idea of these developments. The growing importance of photogrammetry and its numerous applications should be frequently mentioned. The awareness of a national survey control net, of the federal agencies who execute precision surveys and produce maps, and a general appreciation of the state-wide system of plane coordinates should be stimulated. The latest instrumental developments will attract the interest of most students. The optical theodolite is gaining increased acceptance among American engineers and the prismatic and pendulum astrolabes are supplanting, to some extent, the more conventional instruments for determining astronomic position. Short-wave radio for survey communication, the use of Shoran, Loran, and Radar, and the electric analogue for adjusting survey data will provoke much discussion. Surveying and mapping are of the highest strategic importance in modern warfare. Only those who have seen the comprehensive terrain studies that were prepared for our invasion forces can appreciate the magnitude of the task and the consummate skill with which it was accomplished under the direction of men who were trained as civil engineers.

There is a compelling reason to provide less descriptive material in lectures. No matter how gifted a speaker you may be, your message to your students cannot always be very inspiring. Moreover, a student grasps and retains descriptive material better through the medium of a well-written text than he can by listening to a lecture. Make more use of the class-room time to provoke a discussion of timely topics, the matter of errors and the problem of balancing increased accuracy with additional cost, map specifications, registration of surveyors, and recent articles from the technical literature. It has been frequently observed that too many graduate civil engineers in the practice of surveying do not know when to "hold to the line or round the corner." Refinement in measurements is not always necessary and the judgment of the student should be somewhat shaped concerning this by the end of his surveying instruction.

A realistic treatment of surveying and mapping in the advanced course could be achieved by considering all phases of a large surveying project. The complete sequence of operations could be studied in detail beginning with the conception of the project and the preliminary estimate of survey costs. Such operations could begin with the determination of position, the execution of horizontal and vertical control of different orders, continue with the detail surveys, both ground and aerial, and conclude with the plotting and reproduction of the final map, the compilation of the data, and the preparation of a final report. Modern map and chart reproduction is scarcely mentioned in the class room yet poor map reproduction can vitiate the results of the best-managed ground surveys. As interest is developed beyond the content of the required courses, opportunity should be provided for the graduate student in civil engineering to elect further work in Geodetic, Topographic, Land, and Hydrographic Surveying.

In conclusion, the objectives of professional instruction in surveying can be stated as follows:

1. To provide for the acquisition of a good knowledge of surveying theory.
2. To provide opportunity for the attainment of a reasonable degree of skill in using survey equipment.
3. To aid in developing judgment and administrative ability through the direction of party operations.
4. To stimulate in the student a broader understanding and a keener appreciation of the vital role that Surveying and Mapping plays in the practice of Civil Engineering.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 13, 1950	D. S. Clark, Purdue University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
National Capital Area	Washington, D. C.	Oct. 4, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Fall, 1950	F. H. Thomas, University of Buffalo

Candid Comments

SHEARING THE SHEARS

The technique of dramatizing the limitations of theories by application to extreme cases has been mentioned by Professors Midgette, Macduff, and Modrovsky in their article, "On Teaching Creativeness in Design." The example chosen appears to be most unfortunate. Such a "challenge of the maximum shear stress criterion" should have been refuted by any alert student who is not limited to two-dimensional thinking.

Certainly it is acceptable to state that *two* of the principal stresses in a spherical pressure vessel are equal. But the third is zero at the outer surface and negative at the inner surface. Hence the maximum shear stress theory *does not* indicate an "infinite capacity" for the spherical pressure vessel.

As I write this I am wondering if the authors were testing their hearers and readers with a double-barrelled application of the technique described—"encouraging the habit of critically assessing all proposals." On the other hand, I wonder if numerous students have been buffaloed into accepting the erroneous results of an abortive challenge of the maximum shear stress theory.

Yours very truly,

GERALD K. GILLAN,
Assistant Professor
of Civil Engineering,
University of Missouri

In the News

STUDY OF UNDEVELOPED AREAS

A grant of $32,500 was made to **Michigan State College** for a study of problems involved in technical assistance to economically underdeveloped areas. Through its Social Research Service, the College is developing a program of research and training in agricultural extension methods in cooperation with the Inter-American Institute of Agricultural Sciences in Costa Rica. Under the present grant, Dr. Loomis, Director of the Service, plans to extend both the research and training activities to other parts of Latin America.

E.C.P.D. OFFICERS FOR 1949–1950 ANNOUNCED

Harry S. Rogers, President, The Polytechnic Institute of Brooklyn, was elected Chairman of the Engineers' Council for Professional Development, a conference body of engineering organizations of the United States and Canada, at its 17th Annual Meeting held at the Edgewater Beach Hotel, Chicago, Illinois, October 28–29, 1949. Dr. Rogers succeeds James W. Parker, president, The Detroit Edison Company, who has been chairman for the past three years. Other officers elected were: Vice-chairman, L. F. Grant, Queen's University and Royal Military College; Secretary, C. E. Davies, Secretary of the American Society of Mechanical Engineers; Assistant Secretary, William N. Carey, Secretary of the American Society of Civil Engineers.

Dr. Rogers is the seventh chairman to be elected since the E.C.P.D. was organized in 1932. Before his election as chairman, he served for two years as vice-

chairman of the Council. For the past five years he has represented The American Society for Engineering Education on E.C.P.D. From 1944 to 1946 Dr. Rogers was President of the Society for the Promotion of Engineering Education which became the American Society for Engineering Education in 1946. Other representatives of this society on the E.C.P.D. include W. R. Woolrich and H. T. Heald.

COLLEGE ENROLLMENTS

Enrollments in the Nation's colleges and universities continued to show an increase in the face of a declining number of veteran students, according to a report released today by Federal Security Administrator Oscar R. Ewing. Total enrollment in the fall of 1949 stands at 2,456,000 students, as compared with 2,408,000 a year ago, he said.

The data released are based on the survey of college and university enrollments conducted each fall by the Office of Education, Federal Security Agency. Earl James McGrath, U. S. Commissioner of Education, points out that the data reported in this survey reflect enrollment in every higher educational institution in the United States and its outlying parts. Information has been furnished by registrars of 1809 institutions of higher learning throughout the United States. Estimates are included for 40 institutions that failed to respond.

The rate of student drop-out is slowing down, according to the Office of Education survey. This is shown by the fact that total enrollment has gone up, despite a decrease in the number of new or freshman students. Veterans comprised almost half of the Nation's college student body in 1947. This year veterans account for only 35 per cent of the total enrollment. Approximately 55 per cent of the veterans are enrolled in 131 of the country's large universities. Last year the same institutions enrolled about 50 per cent of the veteran student body.

On the college campuses this fall the men outnumber the women a little over 2 to 1. Percentage-wise, the gain in the number of men students in 1949 over 1948 was less than 1 per cent while the number of women students increased almost 5 per cent. This fall there were 1,728,000 men and 728,000 women enrolled.

The ten institutions with the largest enrollments reported are: New York University, 47,936; University of California, 43,426; The City College of New York, 30,192; Columbia University, 29,153; University of Minnesota, 25,084; University of Illinois, 25,062; Northwestern University, 22,822; Ohio State University, 22,416; Indiana University, 21,826; and the University of Wisconsin, 20,796.

Sections and Branches

The first meeting of the **Case Branch** of the A.S.E.E. for the school year was held on November 16th with about 60 faculty members present. The general topic was "What Makes Effective Teaching?", and the Panel-Topic was "Speaking Techniques." New officers for the year 1949–50 were elected as follows: Chairman, O. M. Stone; Vice Chairman, R. C. Putnam; Secretary-Treasurer, W. A. Lynam.

New Members

ALLEN, PHILIP, Assistant Professor of Mechanical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, G. H. Auth.

ARCHER, LAWRENCE H., Instructor in Mathematics, Ohio Northern University, Ada, Ohio. A. R. Webb, J. A. Weishampel.

BARTH, THOMAS S., Assistant Professor of Civil Engineering, University of Houston, Houston, Tex. C. A. Vogt, W. B. Lowe.

BEESON, CARROL M., Associate Professor of Petroleum Engineering, University of Southern California, Los Angeles, Calif. R. C. Brinker, P. H. McGauhey.

BEGGS, JOSEPH S., Assistant Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

BLAKESLEE, T. R., Instructor in Mechanical Engineering, Lafayette College, Easton, Pa. J. E. Rush, W. F. Slantz.

BLAKESTAD, ROBERT B., Head, Dept. of Engineering, Arkansas State College, State College, Ark. G. F. Branigan, R. C. Wray.

BRILLINGER, C. L., Director of Training and Education, York Corporation, York, Pa. B. G. Elliott, M. O. Withey.

CONWAY, J. B., Assistant Professor of Chemical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, A. B. Bronwell.

COX, GEORGE B., Head, Industrial Engineering and Industrial Arts, Oregon State College, Corvallis, Ore. G. W. Gleeson, F. O. McMillan.

CROUSE, DAVID P., Instructor in Graphics, Lafayette College, Easton, Pa. J. E. Rush, F. W. Slantz.

DAVIS, W. KENNETH, Associate Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

ENGESSER, WILLIAM F., Associate Professor of Industrial Engineering, Oregon State College, Corvallis, Ore. A. L. Albert, F. O. McMillan.

FAUCETT, THOMAS R., Instructor in Mechanical Engineering, Purdue University, Lafayette, Indiana. E. S. Ault, A. R. Holowenko.

FISCHER, FREDERIC P., Professor and Head, Electrical Engineering, University of Buffalo, Buffalo, N. Y. L. E. Williams, G. S. Timoshenko.

GAMZUE, BENJAMIN B., Instructor in English, New York University, New York 3, N. Y. D. B. Porter, H. Torgersen.

GATLEY, WALTER R., Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. C. G. Pellar, R. W. Sauer.

GIDDINGS, HORACE A., Professor of Mathematics, New York University, New York, N. Y. Thorndike Saville, A. B. Bronwell.

GISEL, EUGENE A., Chairman, Chemistry Dept., Fordham University, New York, N. Y. Thorndike Saville, W. F. O'Connor.

GREGORY, CARL E., Professor of Social Studies, New York University, New York, N. Y. D. B. Porter, C. W. Lytle.

HALL, H. LAWRENCE, Associate Professor of Industrial Engineering, University of Wichita, Wichita, Kans. K. Rozak, M. H. Snyder, Jr.

HAMPTON, WILLIAM C., Assistant Professor of Mechanical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, C. O. Georgi.

HARMAN, WILLIS W., Associate Professor, Electrical Engineering, University of Florida, Gainesville, Fla. F. H. Pumphrey, H. E. Schweyer.

HARROUN, DALE T., Associate Professor of Civil Engineering, University of Pennsylvania, Philadelphia, Pa. H. T. Bowman, A. Jorgensen.

HASSLER, GERALD L., Lecturer, Engineering, University of California, Los Angeles, California. W. L. Orr, C. M. Duke.

HERSHBERGER, WILLIAM D., Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

HIMELRIGHT, LORING K., Assistant Professor of Civil Engineering, The Citadel, Charleston, S. C. G. J. Hutto, R. A. Kessler, Jr.

JONES, ARNOLD P., Professor of Mathematics, Milwaukee School of Engineering, Milwaukee, Wis. S. A. Eng, K. O. Werwath.

JONES, JAMES O., Assistant Professor and Acting Head, Engineering and Mathematics Depts., University of Tennessee Jr. College, Martin, Tenn. W. C. Taylor, Jr., A. B. Bronwell.

JOPPA, ROBERT G., Instructor in Aeronautical Engineering, University of Washington, Seattle, Wash. F. S. Eastman, F. B. Farquharson.

KELLY, FRANCIS J., Instructor in Electrical Engineering, Ohio Northern University, Ada, Ohio. A. R. Webb, J. A. Weishampel.

KERR, ALFRED A., Associate Professor of Engineering, Lafayette College, Easton, Pa. C. M. Merrick, J. E. Rush.

KING, ELLIS F., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

KLINGENBERGER, JAMES, Instructor in Electrical Engineering, Ohio Northern University, Ada, Ohio. A. R. Webb, J. A. Weishampel.

KNAPP, WILLIAM J., Assistant Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

KOOS, PAUL V., Laboratories Staff, Technical Employment Dept., Bell Telephone Labs., Inc., New York, N. Y. H. P. Smith, R. A. Deller.

LAGO, GLADWYN V., Assistant Professor of Electrical Engineering, University of Missouri, Columbia, Mo. J. C. Hogan, H. L. Seneff.

LANE, ROBERT D., Assistant to the Director of Engineering, Sinclair College, Dayton, Ohio. R. C. Klas, P. C. Snyder.

LEWIS, AMBROSE B., Instructor in Agricultural Engineering, Lincoln University, Jefferson City, Mo. W. Jackson, J. N. Freeman.

MACDONALD, FRANK W., Associate Professor of Electrical Engineering, University of Florida, Gainesville, Fla. F. H. Pumphrey, H. E. Schweyer.

MANILDI, JOSEPH F., Assistant Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

MCCUTCHAN, JOSEPH W., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

MCMILLIN, KENNETH M., Instructor in Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. G. C. Priester, E. S. Loye.

MILLER, MARSHALL L., Professor and Head, Engineering Placement, Speed Scientific School, Louisville, Ky. H. H. Fenwick, R. C. Ernst.

MOORE, ROBERT J., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. O. W. Potter, S. G. Palmer.

MORROW, HAROLD W., Instructor in Engineering Mechanics, University of Florida, Gainesville, Fla. G. P. Boomsliter, T. O. Neff.

MUNI, HARRY W., Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. C. W. Merrick, J. E. Rush.

NEWLIN, CHARLES W., Instructor in Civil Engineering, Swarthmore College, Swarthmore, Pa. S. T. Carpenter, R. F. Linsenmeyer.

OWENS, BERL W., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. L. B. Cooper, B. T. McMinn.

PARKER, MERTON C., Instructor in Engineering, University of Portland, Portland, Ore. J. R. Griffith, J. C. Othus.

PILLSBURY, ARTHUR F., Associate Professor of Agriculture, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

POLENTZ, LLOYD M., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

PRESCOTT, WALLACE S., Assistant Professor of Civil Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. D. W. Mattson, J. M. Henderson.

RAWLES, CHARLES M., Supervisor, Technical Placement, Allis-Chalmers Mfg. Company, Milwaukee, Wis. C. S. Haagensen, J. L. Singleton.

REIN, DAVID M., Instructor in Language and Literature, Case Institute of Technology, Cleveland, Ohio. R. L. Shurter, O. M. Stone.

SAWYER, WILLIAM L., Professor of Engineering Mechanics, University of Florida, Gainesville, Fla. G. P. Boomsliter, T. O. Neff.

SEMELSBERGER, ROBERT, Instructor in Electrical Engineering, Villanova College, Villanova, Pa. D. W. Davis, J. S. Morehouse.

SEYER, WILLIAM F., Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

SHELDON, ROBERT C., Associate Professor of Civil Engineering, Ohio Northern University, Ada, Ohio. A. R. Webb, J. A. Weishampel.

SINGER, DAVID, Instructor in Drafting, City College of New York, New York, N. Y. G. C. Autenreith, W. L. Stork.

SMIRNOFF, MICHAEL V., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

SMITH, BERNARD, Assistant Professor of Civil Engineering, Lafayette College, Easton, Pa. J. E. Rush, F. W. Slantz.

STEINER, CELESTIN J., S.J., President, University of Deroit, Detroit, Michigan. C. J. Freund, J. Gerardi.

STEPHENSON, SEYMOUR T., Professor of Physics, The State College of Washington, Pullman, Wash. H. A. Sorensen, A. B. Bronwell.

SWINK, CLYDE W., Instructor, University of Louisville, Ky. H. H. Fenwick, R. C. Ernst.

THURSTON, JAMES N., Associate Professor of Electrical Engineering, University of Florida, Gainesville, Fla. H. E. Schweyer, F. H. Pumphrey.

VERNON, JAMES B., Assistant Professor of Engineering, University of Southern California, Los Angeles, Calif. R. C. Brinker, P. H. McGauhey.

WASEL, ALBERT D., Assistant Professor of Mathematics, University of Santa Clara, Santa Clara, Calif. R. M. Hermes, G. L. Sullivan.

WHITTEMORE, RICHARD R., Technology Editor, Washington State Institute of Technology, State College of Washington, Pullman, Wash. W. A. Pearl, H. A. Sorensen.

WILLIAMS, ROBERT J., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. G. Dobbins, W. S. Beattie.

WOLF, WILLIAM W., Assistant Professor of Chemical Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, R. F. Heckman.

WRIGHT, JOHN S., Instructor in Civil Engineering, Lafayette College, Easton, Pa. J. Martinsen, J. E. Rush.

ZIMNEY, CHARLES M., Assistant Professor of Aeronautical Engineering, University of Minnesota, Minneapolis, Minn. W. W. Harris, L. G. Kircher.

424 New members elected this year.

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

Seattle, Wash. **June 19–23, 1950**

1949 Enrollment in Engineering Colleges

By ROBERT C. STORY and HENRY H. ARMSBY *

Approximately 198,000 engineering students were enrolled this fall in the 141 [1] schools accredited by the Engineers' Council for Professional Development. Undergraduate students numbered 180,646 while 15,079 were studying for the master's degree. There were 2,541 students pursuing work leading to the doctor's degree.

When enrollment in E.C.P.D. accredited schools is combined with that of other U. S. engineering schools, the number of undergraduate students is increased to 201,927.

Engineering students constitute about 9 per cent of all college and university students in the United States, as reported by the U. S. Office of Education.[2]

The 141 institutions accredited by the E.C.P.D., together with 39 other U. S. engineering schools, conferred, during the year ending June 30, 1949, a total of 45,200 bachelor's degrees in engineering, 4,798 master's and professional degrees, and 417 doctorates. These constitute 12 per cent of all bachelor's degrees conferred by U. S. colleges and universities, 9.5 per cent of all master's degrees, and 8 per cent of all doctorates, as reported by the U. S. Office of Education.[3]

The distribution of undergraduate enrollment among the four principal curricula for U. S. schools accredited by the E.C.P.D. is as follows: mechanical engineering, 42,758; electrical engineering, 40,946; civil engineering, 27,135; and chemical engineering, 17,392. Together these four curricula enroll 71 per cent of the total undergraduate engineering students. In the American Society for Engineering Education report for the fall of 1948 they enrolled 63 per cent of the undergraduate students in a slightly different group of institutions.

These data are based on a survey of engineering schools and colleges made in October 1949 under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by a joint committee of the Office of Education and the A.S.E.E., all institutions which are listed in the U. S. Office of Education Directory of Higher Education [4] and which reported that they conferred degrees in engineering during the year 1948–49 [5] were requested to supply data. Eleven Canadian institutions were also included. Replies were received from all institutions accredited by the E.C.P.D., from 39 other U. S. institutions, and from 8 in Canada.

* Of the U. S. Office of Education. Mr. Story is Head, Technical Services Unit, Research and Statistical Service, and Mr. Armsby is Associate Chief for Engineering Education, Division of Higher Education.

[1] The Seventeenth Annual Report (October 28, 1949) of the Engineers' Council for Professional Development listed 140 institutions as accredited. The University of California, Berkeley, and the University of California at Los Angeles were considered as one institution. In this report, however, the University of California and the University of California at Los Angeles are treated separately.

[2] 1949 Fall Enrollment in Higher Educational Institutions, Circular No. 264, November 10, 1949, U. S. Office of Education.

[3] Story, Robert C., "Earned Degrees Conferred in Higher Educational Institutions, 1948–49," Circular No. 262, U. S. Office of Education, November, 1949.

[4] *Education Directory, Part III, Higher Education, 1948–49.*

[5] Story, Robert C., *Ibid.*

As proposed by the joint A.S.E.E. and Office of Education Committee and approved by the A.S.E.E. General Council, the tabulations in this report list individually only the E.C.P.D. accredited institutions (eligible for active institutional membership in the A.S.E.E.), but contain data for the other U. S. institutions as a group and for the Canadian institutions as a group. Detailed data for these two groups of institutions will be made available by the U. S. Office of Education.

The enrollment data for the 180 institutions in the 1949 report are not directly comparable to previous data published annually in the JOURNAL OF ENGINEERING EDUCATION. However, the E.C.P.D. accredited list in the 1949 report is quite similar to the list of schools published in previous reports. This is

ENGINEERING STUDENTS ENROLLED IN U. S. AND CANADIAN INSTITUTIONS, AND DEGREES CONFERRED

Item	Number of Schools	Number Enrolled, Fall 1949			Degrees Conferred, 1948–49
		Men	Women	Total	
(1)	(2)	(3)	(4)	(5)	(6)
Enrolled in ECPD accredited schools:					
Undergraduate (bachelor's)	141	180,009	637	180,646	41,793
Graduate (master's)	113	15,005	74	15,079	4,783
(doctor's)		2,531	10	2,541	417
Enrolled in other U. S. schools:					
Undergraduate (bachelor's)	39	21,240	41	21,281	3,407
Graduate (master's)	6	160	1	161	15
(doctor's)		4	0	4	0
Enrolled in all U. S. schools:					
Undergraduate (bachelor's)	180	201,249	678	201,927	45,200
Graduate (master's)	119	15,165	75	15,240	4,798
(doctor's)		2,535	10	2,545	417
Enrolled in Canadian schools:					
Undergraduate (bachelor's)	8	6,635	19	6,654	1,734
Graduate (master's)	8	163	0	163	47
(doctor's)		4	0	4	1
Enrolled in U. S. and Canadian schools:					
Undergraduate (bachelor's)	188	207,884	697	208,581	46,934
Graduate (master's)	127	15,328	75	15,403	4,845
(doctor's)		2,539	10	2,549	418

evident from the fact that, of the 146 reporting schools in 1948, 137 are included in the 1949 list of E.C.P.D. accredited schools. The changes in listings alone would cause the 1949 undergraduate enrollment in E.C.P.D. accredited schools to be approximately 4 per cent less than the enrollment in the 1948 and previous reports. The changes in listings have negligible effect upon graduate enrollment.

It is hoped that the comparisons which follow, based on "matched institutions," will suffice to preserve trends until next year when the coverage of this year will be continued, and two sets of strictly comparable data will be available for continuing comparison. The matched institutions are 140 E.C.P.D. accredited institutions whose reports for the two years are in comparable form. These 140 institutions in 1949 enrolled 92 per cent of the undergraduate engineering students of the United States, and 97 per cent of the graduate students. During 1948–49 they granted 94 per cent of the undergraduate engineering degrees and 98 per cent of the graduate degrees in engineering.

The enrollment reported by these matched institutions shows a decline from 1948 to 1949 of 14.2 per cent in the total number of undergraduate students. By class level, the 1949 freshmen class is down 13 per cent from 1948, while the sophomore and junior classes have decreased about 27 per cent each. The senior class, however, is up about 18 per cent in 1949 over 1948.

Carrying the analysis of matched institutions into the graduate level, it is noted that 13 per cent more students are enrolled in courses leading to the master's degree in 1949 than in 1948. For the same period, the number of students studying for their doctorates increased 22 per cent.

Degree data from the matched institutions show the number of first engineering degrees to be 59 per cent greater in 1949 than in 1948. The number of master's degrees increased about 10 per cent, while the increase in the number of doctor's degrees was in excess of 60 per cent.

Definition of items:

Period covered: Engineering schools were asked to report student enrollment as of October 7, 1949. Some institutions, however, because of late opening, were unable to report before late November. It may be said, therefore, that the enrollment reported represents fall enrollment rather than enrollment as of a specific day.

Undergraduate students: Institutions were requested to "Report all students working for their first engineering degree, whether enrolled on campus or in extension centers (branches or off-campus centers of the college or engineering school). Include only students who are *enrolled definitely as candidates* for an engineering degree. . . ."

Graduate students: Institutions were requested to "Report all students who have been admitted to formal graduate standing—regardless of the number of credit-hours carried by the students and regardless of whether the student's work is administered by the engineering college or the Graduate School. . . ."

Veterans: No data were collected in this survey for veterans as a separate group.

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENT

(for United States only)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Yr.	Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	12,945	108,291	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	17,766	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	16,912	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)

Graduate Enrollment

	Master's Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)

	1940	1947	1948	1949
Total college enrollment in U. S.	1,490,000	2,333,000	2,410,000	2,456,000
Engineering enrollment in U. S.	113,497	244,390	241,554	187,970*
Per cent engineering to total	7.6%	10.5%	10%	7.7%*

* Includes only ECPD accredited institutions. Changes in listings account for less than 4 per cent decrease in 1949 undergraduate enrollments as compared with previous years, but have negligible effect upon graduate enrollment.

Undergraduate Engineering Students, Enrollment as of October 7, 1949

Engineering Curricula	No. of Schools	Number Enrolled in Work for Their First Engineering Degree														No. of First Engineering Degrees Conferred 1948–49	
		Freshmen (1st yr.)		Sophomores (2nd yr.)		Juniors (3rd yr.)		Seniors (4th yr.)		5th yr. (of 5-yr. Curriculum)		Evening Students		Total			
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Schools accredited by ECPD:																	
01 Aeronautical	43	1164	5	1154	15	1198	9	1385	13	59	1	177	2	5137	45	1410	19
02 Agricultural	34	489	—	457	—	608	—	633	1	13	—	—	—	2200	1	429	—
03 Architectural	31	904	15	1056	19	1099	13	1206	14	166	3	59	—	4490	64	703	13
04 Ceramic	13	140	3	190	1	223	—	330	1	4	1	—	—	887	6	190	3
05 Chemical	102	3210	16	3687	14	4181	26	4671	13	362	6	1144	62	17255	137	4114	21
06 Civil	130	4658	10	5838	17	6919	12	7864	13	234	2	1539	29	27052	83	6105	14
07 Electrical	130	6182	8	7992	13	9670	9	12967	12	530	2	3548	13	40889	57	10297	17
08 Engineering Mechanics	2	8	—	17	—	24	—	14	—	—	—	—	—	63	—	10	—
09 Engineering Physics	29	305	4	437	1	425	1	492	2	17	1	31	—	1707	9	345	7
10 General Engineering	26	906	—	797	1	907	3	1370	3	16	—	582	2	4578	9	1150	—
11 Industrial[1]	52	755	—	1321	3	1936	5	2811	5	139	1	483	—	7445	14	2491	2
12 Mechanical	126	6345	11	8313	9	10747	21	12920	24	653	6	3704	5	42682	76	11595	25
13 Metallurgical	45	493	—	622	3	792	1	1013	1	38	1	162	—	3120	6	735	2
14 Mining	34	466	1	524	—	515	—	639	1	6	—	—	—	2150	2	360	1
15 Naval Arch. & Marine	5	37	—	57	—	101	—	81	—	—	—	—	—	276	—	72	1
16 Petroleum	22	1014	—	924	—	964	1	1135	—	16	—	1	—	4054	1	748	1
17 Sanitary	6	6	—	7	—	16	—	38	—	—	—	—	—	67	—	24	—
18 Unclassified	74	6899	27	1077	4	209	2	55	—	—	—	1646	31	9886	64	103	—
19 Others	52	2418	9	1068	10	1056	2	1250	14	48	1	231	27	6071	63	773	13
Total E.C.P.D.	141	36399	109	35538	110	41590	105	50874	117	2301	25	13307	171	180009	637	41654	139
Other U. S. Schools	39	5347	8	3899	11	4370	12	4699	8	337	1	2588	1	21240	41	3398	9
All U. S. Schools	180	41746	117	39437	121	45960	117	55573	125	2638	26	15895	172	201249	678	45052	148
Canadian Schools	8	1215	3	1167	7	1610	7	2317	2	326	—	—	—	6635	19	1732	2
Grand Total (U. S. & Canada)	188	42961	120	40604	128	47570	124	57890	127	2964	26	15895	172	207884	697	46784	150

[1] Includes administrative engineering, management engineering, etc.

Undergraduate Engineering Students, Enrollment as of October 7, 1949

School	No. of Schools in State	Number Enrolled in Work for Their First Engineering Degree														No. of First Engineering Degrees Conferred 1948–49	
		Freshmen (1st yr.)		Sophomores (2nd yr.)		Juniors (3rd yr.)		Seniors (4th yr.)		5th yr. (of 5-yr. Curriculum)		Evening Students		Total			
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
ECPD accredited schools:																	
Ala. Poly.		422	1	368	—	370	2	506	2	—	—	—	—	1666	5	569	1
Univ. Ala.		329	2	201	1	282	1	244	—	—	—	—	—	1056	4	322	—
Alabama Total	2	751	3	569	1	652	3	750	2	—	—	—	—	2722	9	891	1
Arizona Univ.		206	1	188	2	226	—	274	—	—	—	—	—	894	3	134	—
Arizona Total	1	206	1	188	2	226	—	274	—	—	—	—	—	894	3	134	—
Arkansas Univ.		95	—	124	—	200	—	263	1	—	—	—	—	682	1	150	—
Arkansas Total	1	95	—	124	—	200	—	263	1	—	—	—	—	682	1	150	—
Calif. Tech.		171	—	86	—	82	—	98	—	—	—	—	—	437	—	124	—
Stanford		125	—	163	—	211	—	220	—	—	—	—	—	719	—	238	—
Univ. Calif.		211	2	355	1	765	5	1178	6	—	—	—	—	2509	14	760	3
Univ. Cal. Los Ang.		157	2	181	—	252	1	161	1	—	—	—	—	751	4	202	—
Santa Clara		72	—	63	—	87	—	68	—	7	—	—	—	297	—	45	—
Univ. S. Calif.		72	—	166	1	532	—	722	3	—	—	—	—	1492	4	503	1
California Total	6	808	4	1014	2	1929	6	2447	10	7	—	—	—	6205	22	1872	4
Colo. A. & M.		136	—	115	—	145	—	206	—	—	—	—	—	602	—	110	—
Colo. Mines		235	—	286	1	253	—	279	—	—	—	—	—	1053	1	242	1
Colo. Univ.		319	4	414	6	577	3	693	7	—	—	618	1	2621	21	521	11
Denver Univ.		119	—	130	1	193	1	274	1	—	—	6	—	722	3	163	2
Colorado Total	4	809	4	945	8	1168	4	1452	8	—	—	624	1	4998	25	1036	14
U. S. Coast Guard		149	—	134	—	73	—	68	—	—	—	—	—	424	—	54	—
Conn. Univ.		310	—	272	2	282	—	274	—	—	—	—	—	1138	2	129	—
Yale		200	—	247	—	251	—	363	—	—	—	—	—	1061	—	404	—
Connecticut Total	3	659	—	653	2	606	—	705	—	—	—	—	—	2623	2	587	—
Univ. Delaware		99	1	121	1	144	—	190	—	—	—	—	—	554	2	117	—
Delaware Total	1	99	1	121	1	144	—	190	—	—	—	—	—	554	2	117	—
Florida Univ.		475	—	425	—	208	2	308	—	—	—	—	—	1416	2	197	—
Florida Total	1	475	—	425	—	208	2	308	—	—	—	—	—	1416	2	197	—

Georgia Tech		1096	—	1013	—	757	—	1091	—	32	—	—	—	3989	—	799	—
Georgia Total	1	1096	—	1013	—	757	—	1091	—	32	—	—	—	3989	—	799	—
Idaho Univ.		155	1	128	—	147	—	157	—	—	—	—	—	587	1	101	—
Idaho Total	1	155	1	128	—	147	—	157	—	—	—	—	—	587	1	101	—
Ill. Inst. Tech.		433	—	515	—	828	1	845	3	—	—	3734	107	6355	111	606	—
Northwestern		202	—	167	—	153	1	164	—	135	2	—	—	821	3	249	—
Ill. Univ.		1228	6	1028	6	1143	6	1179	4	—	—	—	—	4578	22	1012	1
Illinois Total	3	1863	6	1710	6	2124	8	2188	7	135	2	3734	107	11754	136	1867	1
Purdue		2214	5	1377	6	1831	12	1905	7	—	—	—	—	7327	30	1931	12
Rose Poly		115	—	101	—	80	—	70	—	—	—	—	—	366	—	189	—
Notre Dame		426	—	218	—	152	—	265	—	—	—	—	—	1061	—	266	—
Indiana Total	3	2755	5	1696	6	2063	12	2240	7	—	—	—	—	8754	30	2386	12
Iowa St. College		536	3	707	3	707	2	769	—	3	—	—	—	2722	8	824	—
St. Univ. Iowa		77	—	82	—	113	—	233	1	—	—	—	—	505	1	182	—
Iowa Total	2	613	3	789	3	820	2	1002	1	3	—	—	—	3227	9	1006	—
Kansas St. Col.		232	—	297	—	354	1	598	—	—	—	—	—	1481	1	374	—
Univ. Wichita		117	—	69	—	43	—	29	—	—	—	—	—	258	—	20	—
Kansas Univ.		193	1	262	2	410	—	512	1	—	—	3	—	1380	4	390	1
Kansas Total	3	542	1	628	2	807	1	1139	1	—	—	3	—	3119	5	784	1
Kentucky Univ.		198	3	254	2	316	1	403	1	—	—	—	—	1171	7	257	—
Louisville		111	—	127	—	133	—	34	—	109	—	—	—	514	—	125	—
Kentucky Total	2	309	3	381	2	449	1	437	1	109	—	—	—	1685	7	382	—
La. Poly. Inst.		190	—	147	—	160	2	127	—	—	—	3	—	627	2	138	—
La. St. Univ.		275	—	281	1	390	2	559	1	—	—	—	—	1505	4	460	—
Tulane Univ.		173	—	126	—	118	—	122	—	—	—	—	—	539	—	107	—
Louisiana Total	3	638	—	554	1	668	4	808	1	—	—	3	—	2671	6	705	—
Maine Univ.		219	—	249	1	304	1	461	—	—	—	—	—	1233	2	259	4
Maine Total	1	219	—	249	1	304	1	461	—	—	—	—	—	1233	2	259	4
Johns Hopkins		147	—	141	—	140	—	156	—	—	—	404	—	988	—	202	—
Maryland Univ.		394	—	323	—	311	—	321	—	—	—	6	—	1355	—	146	—
Maryland Total	2	541	—	464	—	451	—	477	—	—	—	410	—	2343	—	348	—
Harvard		—	—	42	—	25	—	29	—	—	—	—	—	96	—	33	—
Mass. Inst. Tech.		561	—	682	4	836	3	921	2	—	—	—	—	3000	9	987	—
Northeastern		482	2	460	2	525	1	342	3	276	4	—	—	2085	12	210	—
Tufts		186	—	132	—	144	—	141	2	—	—	—	—	603	2	144	1
Mass. Univ.		69	—	120	—	160	—	274	—	—	—	—	—	623	—	20	—
Worcester		208	—	185	—	172	—	194	—	—	—	—	—	759	—	213	—
Massachusetts Total	6	1506	2	1621	6	1862	4	1901	7	276	4	—	—	7166	23	1607	1

Undergraduate Engineering Students, Enrollment as of October 7, 1949—*Continued*

School	No. of Schools in State	Number Enrolled in Work for Their First Engineering Degree														No. of First Engineering Degrees Conferred 1948–49	
		Freshmen (1st yr.)		Sophomores (2nd yr.)		Juniors (3rd yr.)		Seniors (4th yr.)		5th yr. (of 5-yr. Curriculum)		Evening Students		Total			
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Mich. M. & T.		272	—	333	—	313	—	531	1	15	—	4	4	1468	5	461	2
Mich. St. Col.		220	—	238	—	470	2	635	1	—	—	—	—	1563	3	461	—
Univ. Detroit		398	—	340	—	500	1	595	1	292	—	185	—	2310	2	236	—
Mich. Univ.		417	4	562	5	1053	3	1240	4	—	—	—	—	3272	16	845	7
Wayne Univ.		329	1	318	2	279	1	296	4	54	1	—	—	1276	9	162	1
Michigan Total	5	1636	5	1791	7	2615	7	3297	11	361	1	189	4	9889	35	2165	10
Minnesota Univ.		424	2	551	2	853	—	1309	—	25	—	56	1	3218	5	1046	4
Minnesota Total	1	424	2	551	2	853	—	1309	—	25	—	56	1	3218	5	1046	4
Miss. St. Col.		105	—	157	1	189	—	204	—	—	—	—	—	655	1	247	1
Miss. Univ.		48	—	46	—	60	—	34	—	—	—	—	—	188	—	35	—
Mississippi Total	2	153	—	203	1	249	—	238	—	—	—	—	—	843	1	282	1
Mo. Univ.		168	1	199	—	349	1	315	1	—	—	—	—	1031	3	302	—
Mo. Mines		325	1	364	1	594	2	1019	3	—	—	—	—	2302	7	480	1
Wash. Univ. St. L.		208	1	246	2	229	—	306	2	—	—	—	—	989	5	350	1
Missouri Total	3	701	3	809	3	1172	3	1640	6	—	—	—	—	4322	15	1132	2
Mont. Mines		80	—	78	—	86	—	57	—	—	—	—	—	301	—	45	—
Mont. St. Coll.		120	—	236	—	122	—	281	—	—	—	—	—	759	—	182	—
Montana Total	2	200	—	314	—	208	—	338	—	—	—	—	—	1060	—	227	—
Nebraska Univ.		312	1	157	—	316	—	395	2	3	—	—	—	1183	3	310	—
Nebrasks Total	1	312	1	157	—	316	—	395	2	3	—	—	—	1183	3	310	—
Nevada Univ.		134	2	89	—	120	—	44	—	—	—	—	—	387	2	67	—
Nevada Total	1	134	2	89	—	120	—	44	—	—	—	—	—	387	2	67	—
Dartmouth		72	—	62	—	98	—	38	—	27	—	—	—	297	—	41	—
New Hamp. Univ.		183	—	121	—	112	—	160	—	—	—	5	—	581	—	181	—
New Hampshire Total	2	255	—	183	—	210	—	198	—	27	—	5	—	878	—	222	—
Newark		298	3	375	—	397	1	373	2	—	—	962	6	2405	12	336	1
Princeton		146	—	121	—	126	—	142	—	—	—	—	—	535	—	154	—
Rutgers		127	—	140	—	182	—	168	—	—	—	—	—	617	—	163	—
Stevens		321	—	271	—	337	—	356	—	—	—	—	—	1285	—	310	—
New Jersey Total	4	892	3	907	—	1042	1	1039	2	—	—	962	6	4842	12	963	1

New Mex. A. & M.		93	1	102	1	116	1	124	—	—	—	—	—	435	3	76	1
N. Mex. Mines		60	—	52	—	62	—	49	—	3	—	—	—	226	—	19	—
N. Mex. Univ.		222	—	157	2	168	1	211	—	—	—	—	—	758	3	141	1
New Mexico Total	3	375	1	311	3	346	2	384	—	3	—	—	—	1419	6	236	2
Alfred		54	3	65	1	50	—	70	1	—	—	—	—	239	5	37	1
Clarkson		306	—	332	—	325	—	402	—	—	—	—	—	1365	—	251	—
Columbia		—	—	—	—	172	3	256	—	—	—	—	—	428	3	255	2
Cooper Union		109	1	90	—	66	—	104	2	—	—	425	4	794	7	211	1
Cornell		577	4	414	2	367	—	565	4	76	—	—	—	1999	10	589	3
Manhattan		183	—	211	—	329	—	240	—	—	—	—	—	963	—	159	—
N. Y. Univ.		314	—	398	—	460	—	437	—	—	—	1260	2	2869	2	526	—
Brooklyn Poly		319	—	421	—	473	—	401	—	—	—	2121	4	3735	4	398	4
Pratt		71	—	115	2	157	—	204	1	—	—	—	—	547	3	134	1
Rochester		55	—	59	—	58	—	105	—	—	—	—	—	277	—	95	—
Rensselaer		710	2	758	3	1192	4	1173	3	—	—	172	18	4005	30	751	5
Syracuse		214	1	276	3	459	2	623	4	—	—	—	—	1572	10	329	2
City Col. of N. Y.		746	11	528	3	588	1	861	10	—	—	1435	12	4158	37	708	6
Union		93	—	79	—	89	—	117	—	—	—	88	—	466	—	77	—
Webb Inst.		18	—	11	—	15	—	19	—	—	—	—	—	63	—	5	—
New York Total	15	3769	22	3757	14	4800	10	5577	25	76	—	5501	40	23480	111	4525	25
Duke		114	—	87	—	104	—	113	1	—	—	—	—	418	1	107	—
N. Caro. St. Coll.		452	1	454	2	385	—	682	1	—	—	—	—	1973	4	625	—
North Carolina Total	2	566	1	541	2	489	—	795	2	—	—	—	—	2391	5	732	—
N. Dak. Ag. Col.		111	—	120	—	138	—	163	—	1	—	—	—	533	—	137	—
N. Dak. Univ.		51	—	70	—	101	—	150	—	—	—	—	—	372	—	78	—
North Dakota Total	2	162	—	190	—	239	—	313	—	1	—	—	—	905	—	215	—
Case		309	—	363	—	351	—	548	1	—	—	—	—	1571	1	594	—
Fenn		208	—	128	—	144	—	57	1	162	2	669	10	1368	13	192	—
Ohio St. Univ.		551	5	469	1	558	—	911	2	284	8	91	—	2864	16	561	6
Akron		109	1	84	—	59	—	98	—	56	1	—	—	406	2	96	1
Cincinnati		384	1	320	—	345	2	348	—	319	3	—	—	1716	6	307	6
Toledo		138	—	117	—	171	2	306	1	—	—	225	—	957	3	149	—
Ohio Total	6	1699	7	1481	1	1628	4	2268	5	821	14	985	10	8882	41	1899	13
Okla. A. & M.		335	1	293	4	497	3	796	5	—	—	10	—	1931	13	387	—
Okla. Univ.		536	3	581	6	671	2	852	—	—	—	—	—	2640	11	454	5
Tulsa		209	—	202	—	171	—	135	—	—	—	—	—	717	—	112	1
Oklahoma Total	3	1080	4	1076	10	1339	5	1783	5	—	—	10	—	5288	24	953	6
Oregon State		183	—	273	—	305	—	589	1	—	—	—	—	1350	1	408	2
Oregon Total	1	183	—	273	—	305	—	589	1	—	—	—	—	1350	1	408	2

Undergraduate Engineering Students, Enrollment as of October 7, 1949—*Continued*

School	No. of Schools in State	Number Enrolled in Work for Their First Engineering Degree														No. of First Engineering Degrees Conferred 1948–49	
		Freshmen (1st yr.)		Sophomores (2nd yr.)		Juniors (3rd yr.)		Seniors (4th yr.)		5th yr. (of 5-yr. Curriculum)		Evening Students		Total			
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Bucknell		110	2	98	—	97	1	180	—	—	—	—	—	485	3	141	1
Carnegie		309	—	302	—	276	—	367	1	—	—	6	—	1260	1	422	—
Drexel Inst.		371	2	348	3	265	1	283	1	160	3	—	—	1427	10	380	2
Lafayette		169	—	222	—	156	—	213	—	—	—	—	—	760	—	182	—
Lehigh		434	—	374	—	332	—	401	—	—	—	—	—	1541	—	506	—
Pa. State Col.		974	1	901	—	641	1	984	2	—	—	—	—	3500	4	707	5
Swarthmore		24	—	28	1	29	—	53	—	—	—	—	—	134	1	46	1
Penna. Univ.		102	—	159	—	118	—	181	—	—	—	—	—	560	—	187	—
Pittsburgh		349	—	448	—	481	1	639	—	—	—	357	2	2274	3	685	1
Villanova		167	—	117	—	145	—	294	—	—	—	—	—	723	—	163	—
Pennsylvania Total	10	3009	5	2997	4	2540	4	3595	4	160	3	363	2	12664	22	3419	10
Brown		96	1	70	—	109	1	159	—	—	—	—	—	434	2	151	—
R. I. State Col.		150	—	142	1	135	2	190	—	—	—	—	—	617	3	149	4
Rhode Island Total	2	246	1	212	1	244	3	349	—	—	—	—	—	1051	5	300	4
Citadel		112	—	84	—	91	—	162	—	—	—	—	—	449	—	112	—
Clemson		492	—	261	—	244	—	278	—	—	—	—	—	1275	—	378	—
S. Car. Univ.		106	1	66	—	145	—	188	—	—	—	—	—	505	1	143	—
South Carolina Total	3	710	1	411	—	480	—	628	—	—	—	—	—	2229	1	633	—
S. Dak. Mines		144	—	101	—	149	—	189	—	—	—	—	—	583	—	121	—
S. Dak. St. Col.		91	—	113	—	101	—	141	—	—	—	—	—	446	—	98	1
South Dakota Total	2	235	—	214	—	250	—	330	—	—	—	—	—	1029	—	219	1
Tennessee Univ.		243	—	299	1	350	3	383	—	—	—	—	—	1275	4	221	—
Vanderbilt		132	2	124	—	123	3	161	—	—	—	—	—	540	5	257	2
Tennessee Total	2	375	2	423	1	473	6	544	—	—	—	—	—	1815	9	478	2
A. & M. Col. Tex.		1103	—	965	—	857	—	701	—	56	—	—	—	3682	—	1060	—
Texas Western		147	2	105	—	80	—	71	—	—	—	—	—	403	2	44	—
Rice		119	—	115	—	86	—	101	—	—	—	—	—	421	—	118	—
So. Meth. Univ.		159	—	89	1	77	—	133	—	115	—	6	—	579	1	173	—
Texas Tech. Col.		273	—	254	3	293	—	443	2	—	—	—	—	1263	5	328	3
Univ. Texas		379	5	479	8	753	5	875	5	35	1	—	—	2521	24	701	3
Texas Total	6	2180	7	2007	12	2146	5	2324	7	206	1	6	—	8869	32	2424	6

Utah Univ.		186	—	209	—	240	1	249	—	—	—	—	—	884	1	193	—
Utah Agric. Col.		47	—	55	—	41	—	55	—	—	—	—	—	198	—	31	—
Utah Total	2	233	—	264	—	281	1	304	—	—	—	—	—	1082	1	224	—
Norwich		71	—	62	—	72	—	51	—	—	—	—	—	256	—	59	—
Vermont Univ.		79	—	62	—	92	—	116	—	—	—	—	—	349	—	89	1
Vermont Total	2	150	—	124	—	164	—	167	—	—	—	—	—	605	—	148	1
Va. Univ.		75	—	124	1	143	—	127	—	—	—	—	—	469	1	102	—
Va. Mil.		159	—	114	—	106	—	128	—	—	—	—	—	507	—	100	—
Va. Poly. Inst.		665	5	653	2	686	1	864	—	—	—	—	—	2868	8	653	4
Virginia Total	3	899	5	891	3	935	1	1119	—	—	—	—	—	3844	9	855	4
Wash. St. Col.		—	—	161	1	228	—	291	1	38	—	—	—	718	2	174	1
Univ. Wash.		421	1	238	1	372	3	553	—	17	—	—	—	1601	5	430	1
Washington Total	2	421	1	399	2	600	3	844	1	55	—	—	—	2319	7	604	2
W. Va. Univ.		93	—	366	1	369	—	275	—	—	—	—	—	1103	1	264	1
West Virginia Total	1	93	—	366	1	369	—	275	—	—	—	—	—	1103	1	264	1
Marquette		224	—	288	—	341	—	282	—	—	—	—	—	1135	—	330	—
Univ. Wis.		287	—	454	—	628	—	828	—	—	—	—	—	2197	—	610	—
Wisconsin Total	2	511	—	742	—	969	—	1110	—	—	—	—	—	3332	—	940	—
Wyoming Univ.		114	1	98	—	123	1	203	—	—	—	—	—	538	2	170	—
Wyoming Total	1	114	1	98	—	123	1	203	—	—	—	—	—	538	2	170	—
Univ. Alaska		32	1	34	—	15	—	15	—	1	—	—	—	97	1	10	—
Alaska Total	1	32	1	34	—	15	—	15	—	1	—	—	—	97	1	10	—
Catholic Univ.		123	—	187	—	272	—	391	—	—	—	—	—	973	—	163	4
Geo. Wash. Univ.		309	—	219	—	163	—	133	—	—	—	456	—	1280	—	169	—
Howard Univ.		79	—	45	—	50	1	46	—	—	—	—	—	220	1	24	—
Dist. of Columbia Total	3	511	—	451	—	485	1	570	—	—	—	456	—	2473	1	356	4
Total in ECPD accredited schools	141	36399	109	35538	110	41590	105	50874	117	2301	25	13307	171	180009	637	41654	139

Graduate Engineering Enrollment as of October 7, 1949

Engineering Curricula	Number of Schools	Number Enrolled in Work for the Master's Degree								No. of Master's Degrees Conferred in Eng'g 1948–49		Number Enrolled in Work for the Doctor's Degree								No. of Doctor's Degrees Conferred in Eng'g 1948–49	
		Full-Time Day Students		Part-Time Day Students		Evening Students		Total				Full-Time Day Students		Part-Time Day Students		Evening Students		Total			
		Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Schools accredited by ECPD:																					
Aeronautical	35	384	1	139	3	166	1	689	5	302	3	86	—	54	—	16	—	156	—	16	—
Agricultural	17	45	—	47	—	—	—	92	—	45	—	—	—	—	—	—	—	—	—	1	—
Architectural	12	17	—	16	—	6	—	39	—	10	1	—	—	—	—	—	—	—	—	—	—
Ceramic	10	53	3	30	—	—	—	83	3	37	—	12	—	7	—	—	—	19	—	10	1
Chemical	80	1052	5	393	—	518	10	1963	15	746	2	433	1	143	—	29	—	605	1	151	—
Civil	84	811	2	466	—	474	14	1751	16	742	1	139	1	49	—	18	—	206	1	34	—
Electrical	88	1446	3	1558	2	1095	1	4099	6	1076	4	343	1	293	1	22	—	658	2	72	—
Engineering Mechanics	24	119	—	88	—	—	—	207	—	62	—	34	—	38	—	1	—	73	—	8	—
Engineering Physics	15	78	—	44	1	83	1	205	2	56	2	23	1	25	—	2	—	50	1	9	—
General Engineering	5	64	—	23	—	—	—	87	—	19	—	27	1	—	—	—	—	27	1	—	—
Industrial	31	230	—	81	—	605	—	916	—	237	1	31	—	5	—	23	—	59	—	4	—
Mechanical	84	919	1	840	3	830	—	2589	4	862	2	164	—	87	1	29	—	280	1	40	—
Metallurgical	41	233	—	136	1	196	—	565	1	196	1	139	—	48	—	8	—	195	—	34	—
Mining	20	47	—	15	—	—	—	62	—	27	—	7	—	2	—	—	—	9	—	2	—
Naval Arch. & Marine	2	111	—	—	—	—	—	111	—	13	—	37	—	—	—	—	—	37	—	—	—
Petroleum	12	92	—	20	—	1	—	113	—	39	—	5	—	2	—	—	—	7	—	—	—
Sanitary	15	92	—	19	—	—	—	111	—	69	—	16	—	7	—	—	—	23	—	4	—
Unclassified	15	80	—	19	1	439	7	538	8	22	—	—	—	—	—	—	—	—	—	—	—
Others	44	384	5	109	2	292	7	785	14	205	1	89	3	31	—	7	—	127	3	31	—
Total ECPD Schools	113	6257	20	4043	13	4705	41	15005	74	4765	18	1585	8	791	2	155	—	2531	10	416	1
Total other U. S. Schools	6	72	—	14	—	74	1	160	1	15	—	—	—	4	—	—	—	4	—	—	—
Total all U. S. Schools	119	6329	20	4057	13	4779	42	15165	75	4780	18	1585	8	795	2	155	—	2535	10	416	1
Canadian Schools	8	117	—	46	—	—	—	163	—	47	—	2	—	2	—	—	—	4	—	1	—
Grand Total	127	6446	20	4103	13	4779	42	15328	75	4827	18	1587	8	797	2	155	—	2539	10	417	1

Graduate Engineering Enrollment as of October 7, 1949

Institution	Number of Schools in State	Number Enrolled in Work for the Master's Degree								No. of Master's Degrees Conferred in Eng'g 1948–49		Number Enrolled in Work for the Doctor's Degree								No. of Doctor's Degrees Conferred in Eng'g 1948–49	
		Full-Time Day Students		Part-Time Day Students		Evening Students		Total				Full-Time Day Students		Part-Time Day Students		Evening Students		Total			
		Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
ECPD accredited Schools:																					
Ala. Poly		1	—	9	—	—	—	10	—	7	1	—	—	—	—	—	—	—	—	—	—
Univ. Ala.		21	—	—	—	—	—	21	—	8	—	—	—	—	—	—	—	—	—	—	—
Total Alabama	2	22	—	9	—	—	—	31	—	15	1	—	—	—	—	—	—	—	—	—	—
Arizona Univ.		3	—	3	—	—	—	6	—	2	—	—	—	—	—	—	—	—	—	—	—
Total Arizona	1	3	—	3	—	—	—	6	—	2	—	—	—	—	—	—	—	—	—	—	—
Arkansas Univ.		2	—	9	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Arkansas	1	2	—	9	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Calif. Tech.		98	—	—	—	—	—	98	—	134	—	63	—	—	—	—	—	63	—	19	—
Stanford		193	—	—	—	—	—	193	—	139	—	63	—	—	—	—	—	63	—	14	—
Univ. Calif.		206	1	—	—	—	—	206	1	61	—	56	—	—	—	—	—	56	—	—	—
Univ. Cal. Los A.		97	—	—	—	—	—	97	—	12	—	27	1	—	—	—	—	27	1	—	—
Univ. S. Calif.		100	—	52	—	—	—	152	—	45	—	3	—	—	—	—	—	3	—	—	—
Total California	5	694	1	52	—	—	—	746	1	391	—	212	1	—	—	—	—	212	1	33	—
Colo. A. & M.		6	—	—	—	—	—	6	—	5	—	—	—	—	—	—	—	—	—	—	—
Colo. Mines		76	—	—	—	—	—	76	—	15	—	4	—	—	—	—	—	4	—	1	—
Colo. Univ.		78	—	—	—	249	—	327	—	72	—	—	—	—	—	—	—	—	—	2	—
Denver Univ.		6	—	10	—	—	—	16	—	3	—	—	—	—	—	—	—	—	—	3	—
Total Colorado	4	166	—	10	—	249	—	425	—	95	—	4	—	—	—	—	—	4	—	6	—
Conn. Univ.		1	—	16	—	—	—	17	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale		45	—	21	—	—	—	66	—	47	—	33	—	14	—	—	—	47	—	15	—
Total Connecticut	2	46	—	37	—	—	—	83	—	47	—	33	—	14	—	—	—	47	—	15	—
Univ. Delaware		30	—	72	1	—	—	102	1	15	—	10	—	10	—	—	—	20	—	5	—
Total Delaware	1	30	—	72	1	—	—	102	1	15	—	10	—	10	—	—	—	20	—	5	—
Fla. Univ.		42	—	30	—	—	—	72	—	14	—	5	—	4	—	—	—	9	—	—	—
Total Florida	1	42	—	30	—	—	—	72	—	14	—	5	—	4	—	—	—	9	—	—	—
Georgia Tech.		183	—	—	—	—	—	183	—	84	—	16	—	—	—	—	—	16	—	—	—
Total Georgia	1	183	—	—	—	—	—	183	—	84	—	16	—	—	—	—	—	16	—	—	—
Idaho Univ.		18	—	—	—	—	—	18	—	8	—	—	—	—	—	—	—	—	—	—	—
Total Idaho	1	18	—	—	—	—	—	18	—	8	—	—	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment as of October 7, 1949—*Continued*

Institution	Number of Schools in State	Number Enrolled in Work for the Master's Degree								No. of Master's Degrees Conferred in Eng'g 1948–49		Number Enrolled in Work for the Doctor's Degree								No. of Doctor's Degrees Conferred in Eng'g 1948–49	
		Full-Time Day Students		Part-Time Day Students		Evening Students		Total				Full-Time Day Students		Part-Time Day Students		Evening Students		Total			
		Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Ill. Inst. Tech		102	—	19	—	691	20	812	20	71	1	18	—	15	1	18	—	51	1	5	—
Northwestern		66	—	—	—	36	—	102	—	41	—	27	—	—	—	3	—	30	—	8	—
Ill. Univ.		196	—	154	—	—	—	350	—	211	—	73	1	97	—	—	—	170	1	18	1
Total Illinois	3	364	—	173	—	727	20	1264	20	323	1	118	1	112	1	21	—	251	2	31	1
Purdue		132	—	179	—	—	—	311	—	170	1	17	1	76	—	—	—	93	1	25	—
Rose Poly		1	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—
Notre Dame		47	—	—	—	—	—	47	—	25	—	4	—	—	—	—	—	4	—	—	—
Total Indiana	3	180	—	179	—	—	—	359	—	196	1	21	1	76	—	—	—	97	1	25	
Iowa St. College		50	1	71	—	—	—	121	1	70	—	18	—	26	—	—	—	44	—	9	—
St. Univ. Iowa		74	1	9	—	—	—	83	1	60	—	25	—	10	—	—	—	35	—	11	—
Total Iowa	2	124	2	80	—	—	—	204	2	130	—	43	—	36	—	—	—	79	—	20	—
Kansas St. Col.		20	—	54	—	—	—	74	—	15	—	—	—	—	—	—	—	—	—	—	—
Univ. Wichita		4	—	—	—	2	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Kansas Univ.		11	—	39	—	—	—	50	—	22	—	4	—	5	—	—	—	9	—	—	—
Total Kansas	3	35	—	93	—	2	—	130	—	37	—	4	—	5	—	—	—	9	—	—	—
Kentucky Univ.		36	—	4	—	—	—	40	—	7	1	—	—	—	—	—	—	—	—	—	—
Louisville		20	—	14	—	—	—	34	—	16	—	—	—	—	—	—	—	—	—	—	—
Total Kentucky	2	56	—	18	—	—	—	74	—	23	1	—	—	—	—	—	—	—	—	—	—
La. St. Univ.		55	—	27	—	14	—	96	—	26	—	1	—	2	—	—	—	3	—	2	—
Tulane		1	—	10	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Louisiana	2	56	—	37	—	14	—	107	—	26	—	1	—	2	—	—	—	3	—	2	—
Maine Univ.		22	3	13	—	—	—	35	3	10	—	—	—	—	—	—	—	—	—	—	—
Total Maine	1	22	3	13	—	—	—	35	3	10	—	—	—	—	—	—	—	—	—	—	—
Johns Hopkins		83	—	29	—	65	1	177	1	47	—	48	—	22	—	4	—	74	—	9	—
Maryland Univ.		24	—	328	—	—	—	352	—	13	—	7	—	10	—	—	—	17	—	1	—
Total Maryland	2	107	—	357	—	65	1	529	1	60	—	55	—	32	—	4	—	91	—	10	—
Harvard		158	—	17	—	—	—	175	—	215	2	78	—	32	—	—	—	110	—	22	—
Mass. Inst. Tech.		807	1	—	—	—	—	807	1	379	2	322	3	—	—	—	—	322	3	65	—
Northeastern		—	—	—	—	210	—	210	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester		13	—	14	—	—	—	27	—	15	—	—	—	—	—	—	—	—	—	—	—
Total Massachusetts	4	978	1	31	—	210	—	1219	1	609	4	400	3	32	—	—	—	432	3	87	—

Mich. M. & T.		2	—	—	—	—	—	2	—	16	—	—	—	—	—	—	—	—	—	—	—	—
Mich. St. Col.		41	—	29	—	—	—	70	—	37	—	3	—	8	—	—	—	11	—	1	—	—
Mich. Univ.		323	2	61	—	—	—	384	2	323	—	94	—	46	—	—	—	140	—	12	—	—
Wayne		3	—	60	—	—	—	63	—	5	—	—	—	—	—	—	—	—	—	—	—	—
Total Michigan	4	369	2	150	—	—	—	519	2	381	—	97	—	54	—	—	—	151	—	13	—	—
Minnesota Univ.		147	2	77	2	—	—	224	4	77	1	36	—	51	—	—	—	87	—	9	—	—
Total Minnesota	1	147	2	77	2	—	—	224	4	77	1	36	—	51	—	—	—	87	—	9	—	—
Miss. St. Col.		—	—	5	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Miss. Univ.		—	—	2	—	—	—	2	—	4	—	—	—	—	—	—	—	—	—	—	—	—
Total Mississippi	2	—	—	7	—	—	—	7	—	4	—	—	—	—	—	—	—	—	—	—	—	—
Mo. Univ.		—	—	33	—	—	—	33	—	27	—	—	—	—	—	—	—	—	—	—	—	—
Mo. Mines		114	—	—	—	—	—	114	—	33	—	16	—	—	—	—	—	16	—	3	—	—
Wash. Univ. St. L.		177	—	—	—	—	—	177	—	28	—	32	—	—	—	—	—	32	—	1	—	—
Total Missouri	3	291	—	33	—	—	—	324	—	88	—	48	—	—	—	—	—	48	—	4	—	—
Montana Mines		16	—	1	—	—	—	17	—	6	—	—	—	—	—	—	—	—	—	—	—	—
Mont. St. Col.		29	—	—	—	—	—	29	—	18	1	—	—	—	—	—	—	—	—	—	—	—
Total Montana	2	45	—	1	—	—	—	46	—	24	1	—	—	—	—	—	—	—	—	—	—	—
Nebraska Univ.		7	—	21	—	—	—	28	—	7	—	—	—	—	—	—	—	—	—	2	—	—
Total Nebraska	1	7	—	21	—	—	—	28	—	7	—	—	—	—	—	—	—	—	—	2	—	—
New Hamp. Univ.		10	—	—	—	—	—	10	—	3	—	—	—	—	—	—	—	—	—	—	—	—
Total New Hampshire	1	10	—	—	—	—	—	10	—	3	—	—	—	—	—	—	—	—	—	—	—	—
Newark		—	—	9	—	371	3	380	3	4	—	—	—	—	—	—	—	—	—	—	—	—
Princeton		52	—	13	—	—	—	65	—	55	—	24	—	1	—	—	—	25	—	6	—	—
Rutgers		3	—	149	—	—	—	152	—	5	—	—	—	—	—	—	—	—	—	—	—	—
Stevens		26	—	39	2	746	4	811	6	101	1	—	—	—	—	—	—	—	—	—	—	—
Total New Jersey	4	81	—	210	2	1117	7	1408	9	165	1	24	—	1	—	—	—	25	—	6	—	—
New Mex. Mines		—	—	12	—	—	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Mex. Univ.		14	—	47	—	—	—	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total New Mexico	2	14	—	59	—	—	—	73	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alfred		3	1	12	—	—	—	15	1	6	—	—	—	—	—	—	—	—	—	—	—	—
Clarkson		—	—	8	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Columbia		134	—	—	—	207	—	341	—	173	1	112	—	—	—	—	—	112	—	12	—	—
Cornell		84	—	31	1	—	—	115	1	57	—	41	—	20	—	—	—	61	—	8	—	—
N. Y. Univ.		98	—	7	—	539	4	644	4	232	—	16	—	—	—	100	—	116	—	6	—	—
Brooklyn		93	1	999	6	—	—	1092	7	134	2	35	—	123	1	—	—	158	1	12	—	—
Rensselaer		97	—	119	—	72	3	288	3	115	—	5	1	23	—	—	—	28	1	1	—	—
Rochester		7	—	6	—	1	—	14	—	11	—	—	—	—	—	—	—	—	—	—	—	—
Syracuse		31	—	98	—	—	—	129	—	14	—	4	—	3	—	—	—	7	—	—	—	—
City Col. of N. Y.		—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Union		—	—	—	—	54	—	54	—	7	—	—	—	—	—	—	—	—	—	—	—	—
Total New York	11	547	2	1280	7	873	7	2700	16	750	3	213	1	169	1	100	—	482	2	39	—	—
N. Car. St. Col.		104	2	—	—	—	—	104	2	33	—	—	—	—	—	—	—	—	—	—	—	—
Total North Carolina	1	104	2	—	—	—	—	104	2	33	—	—	—	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment as of October 7, 1949—*Continued*

Institution	Number of Schools in State	Number Enrolled in Work for the Master's Degree								No. of Master's Degrees Conferred in Eng'g 1948–49		Number Enrolled in Work for the Doctor's Degree								No. of Doctor's Degrees Conferred in Eng'g 1948–49	
		Full-Time Day Students		Part-Time Day Students		Evening Students		Total				Full-Time Day Students		Part-Time Day Students		Evening Students		Total			
		Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
N. Dak. Univ.		2	—	—	—	—	—	2	—	1	—	2	—	—	—	—	—	2	—	—	—
Total North Dakota	1	2	—	—	—	—	—	2	—	1	—	2	—	—	—	—	—	2	—	—	—
Case		56	1	43	1	314	5	413	7	103	—	9	—	23	—	30	—	62	—	17	—
Ohio St. Univ.		188	1	—	—	259	—	447	1	149	—	70	—	—	—	—	—	70	—	23	—
Cincinnati		45	—	—	—	—	—	45	—	18	—	10	—	—	—	—	—	10	—	10	—
Toledo		—	—	—	—	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Ohio	4	289	2	43	1	576	5	908	8	270	—	89	—	23	—	30	—	142	—	50	—
Okla. A. & M.		69	—	46	—	128	—	243	—	54	—	—	—	—	—	—	—	—	—	—	—
Okla. Univ.		56	1	17	—	—	—	73	1	28	—	—	—	—	—	—	—	—	—	—	—
Tulsa		38	1	—	—	1	—	39	1	13	—	—	—	—	—	—	—	—	—	—	—
Total Oklahoma	3	163	2	63	—	129	—	355	2	95	—	—	—	—	—	—	—	—	—	—	—
Oregon State		34	—	—	—	—	—	34	—	36	—	1	1	1	—	—	—	2	1	2	—
Total Oregon	1	34	—	—	—	—	—	34	—	36	—	1	1	1	—	—	—	2	1	2	—
Bucknell		19	—	4	—	—	—	23	—	5	1	—	—	—	—	—	—	—	—	—	—
Carnegie		86	—	3	—	35	—	124	—	84	—	36	—	10	—	—	—	46	—	11	—
Drexel		—	—	—	—	128	—	128	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh		34	—	17	—	—	—	51	—	33	—	13	—	8	—	—	—	21	—	2	—
Pa. State Col.		47	—	107	—	—	—	154	—	76	1	16	—	44	—	—	—	60	—	12	—
Penna. Univ.		22	—	55	—	437	—	514	—	75	—	12	—	41	—	—	—	53	—	6	—
Pittsburgh		29	—	406	—	—	—	435	—	63	—	13	—	38	—	—	—	51	—	4	—
Total Pennsylvania	7	237	—	592	—	600	—	1429	—	336	2	90	—	141	—	—	—	231	—	35	—
Brown		17	—	—	—	—	—	17	—	6	—	5	—	—	—	—	—	5	—	—	—
R. I. State Col.		9	—	—	—	—	—	9	—	2	—	—	—	—	—	—	—	—	—	—	—
Total Rhode Island	2	26	—	—	—	—	—	26	—	8	—	5	—	—	—	—	—	5	—	—	—
Clemson		2	—	5	—	—	—	7	—	1	—	—	—	—	—	—	—	—	—	—	—
S. Car. Univ.		—	—	6	—	—	—	6	—	1	—	—	—	—	—	—	—	—	—	—	—
Total South Carolina	2	2	—	11	—	—	—	13	—	2	—	—	—	—	—	—	—	—	—	—	—
S. Dak. Mines		6	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. Col.		—	—	1	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—
Total South Dakota	2	6	—	1	—	—	—	7	—	2	—	—	—	—	—	—	—	—	—	—	—

Tennessee Univ.		34	—	44	—	—	—	78	—	18	—	—	—	—	—	—	—	—	—	—	—
Vanderbilt		9	—	—	—	—	—	9	—	6	—	—	—	—	—	—	—	—	—	—	—
Total Tennessee	2	43	—	44	—	—	—	87	—	24	—	—	—	—	—	—	—	—	—	—	—
A. & M. Col. Tex.		101	—	37	—	—	—	138	—	72	—	2	—	6	—	—	—	8	—	2	—
Rice		9	—	8	—	—	—	17	—	14	—	—	—	—	—	—	—	—	—	—	—
So. Meth. Univ.		—	—	—	—	48	1	48	1	—	—	—	—	—	—	—	—	—	—	—	—
Texas Tech. Col.		11	—	—	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Tex.		101	—	68	—	—	—	169	—	68	—	21	—	18	—	—	—	39	—	9	—
Total Texas	5	222	—	113	—	48	1	383	1	154	—	23	—	24	—	—	—	47	—	11	—
Utah Univ.		63	—	—	—	—	—	63	—	24	—	2	—	—	—	—	—	2	—	1	—
Utah Agric. Col.		14	—	6	—	—	—	20	—	11	—	2	—	—	—	—	—	2	—	—	—
Total Utah	2	77	—	6	—	—	—	83	—	35	—	4	—	—	—	—	—	4	—	1	—
Vermont Univ.		—	—	6	—	—	—	6	—	1	—	—	—	—	—	—	—	—	—	—	—
Total Vermont	1	—	—	6	—	—	—	6	—	1	—	—	—	—	—	—	—	—	—	—	—
Va. Univ.		4	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Va. Poly. Inst.		67	—	38	—	—	—	105	—	45	2	2	—	2	—	—	—	4	—	1	—
Total Virginia	2	71	—	38	—	—	—	109	—	45	2	2	—	2	—	—	—	4	—	1	—
Wash. St. Col.		6	—	11	—	—	—	17	—	6	—	—	—	—	—	—	—	—	—	—	—
Univ. Wash.		123	1	11	—	—	—	134	1	37	—	17	—	—	—	—	—	17	—	—	—
Total Washington	2	129	1	22	—	—	—	151	1	43	—	17	—	—	—	—	—	17	—	—	—
W. Va. Univ.		32	—	29	—	—	—	61	—	8	—	1	—	2	—	—	—	3	—	—	—
Total West Virginia	1	32	—	29	—	—	—	61	—	8	—	1	—	2	—	—	—	3	—	—	—
Univ. Wisc.		180	—	—	—	95	—	275	—	77	—	—	—	—	—	—	—	—	—	9	—
Total Wisconsin	1	180	—	—	—	95	—	275	—	77	—	—	—	—	—	—	—	—	—	9	—
Wyoming Univ.		—	—	—	—	—	—	—	—	9	—	11	—	—	—	—	—	11	—	—	—
Total Wyoming	1	—	—	—	—	—	—	—	—	9	—	11	—	—	—	—	—	11	—	—	—
Catholic Univ.		1	—	34	—	—	—	35	—	2	—	—	—	—	—	—	—	—	—	—	—
Total Dist. Columbia	1	1	—	34	—	—	—	35	—	2	—	—	—	—	—	—	—	—	—	—	—
Total ECPD Schools	113	6257	20	4043	13	4705	41	15005	74	4765	18	1585	8	791	2	155	—	2531	10	416	1

Editorial—Looking Ahead with ECPD

By H. S. ROGERS

President of ECPD and President of Brooklyn Polytechnic Institute

It seems wise at this time to review the broad perspective which originally pervaded the organization and the establishment of ECPD and to make a projection of the work for the year in the light of this review. The concept of its founders was to serve in those areas of common professional problems confronting all of the engineering societies where men are banded together for the induction, indoctrination, growth, development and recognition of their professional brothers.

The four principal areas chosen for the organization of the Council's operations were Selection and Guidance, Engineering Schools, Professional Training and Professional Recognition. In these areas it will be observed that all problems are more or less inter-society (common to our constituent members) and intra-professional (within the profession of engineering). In contradistinction to this, the work of EJC is inter-society and extra-professional, dealing as it does with the relationships between engineers and industry, and between engineers and government and public affairs.

Since the founding of ECPD it has not always been clear whether the purpose of its work was to operate in a staff capacity, making plans, providing studies and suggesting action to the constituent members, or to operate in a line or field capacity, executing plans upon its own initiative. The Committee on Selection and Guidance has operated in both manners. The Committee on Engineering Schools has performed an active field service. The Committee on Professional Training has done more work of a staff nature than of a field nature, and the Committee on Professional Recognition has operated almost exclusively as a staff committee. The scope of the program of ECPD will depend upon the judgment of the Council as to this basic nature of its operations and, of course, upon the approval and consent of its constituent bodies. If we are to accept the responsibility of a broad field service we must then devise the kind of field organization which is necessary to execute such a service. How comprehensive this may be will depend upon the energies and abilities that we may be able to recruit or to associate ourselves with.

In approaching the year's work with a broad perspective of intra-professional service primarily within the four areas, many suggestions immediately arise for expanding and advancing the work of our standing committees. The Committee on Selection and Guidance will find it necessary to make a comprehensive study of the present status of these services within the engineering schools, and to promote those practices which we consider sound. To do this it will, of course, be necessary to associate itself with the work of the ASEE, one of our constituent bodies.

The Committee on Engineering Schools might look to a broader field of service which will incorporate a study of the effectiveness of student chapters in the schools and the possibility of giving better professional and vocational service to these chapters. The Committee on Professional Training will find a great challenge in field service which can be coordinated with many groups now operating throughout the country. The Committee on Professional Recognition might undertake the study of professional degrees, of

uniform registration laws, and follow up the matter of adoption of uniform grades of membership.

In order to make progress during the coming year it will be necessary for us in cooperation with the standing committees to select from among needed services certain objectives of a specific nature and to assist in their achievement. To accomplish this it would seem wise to have the chairman of one standing committee present at each meeting of the Executive Committee.

It is also timely for us to review the charter of the Council and, with the perspective now made possible by our experience in the past and that of other organizations such as EJC, re-define our objectives and examine the areas in which we are to operate.

Sections and Branches

Yale University acted as host to the **New England Section of the A.S.E.E.** at its annual fall meeting on October 8, 1949. Numerous conferences were held on the various branches pertaining to engineering. Chairman C. E. Tucker introduced President Thorndike Saville, who commented briefly upon recent developments of the Society at the national level. Other guests included J. S. Thompson, Treasurer of the A.S.E.E., and D. M. Prentice. Nominations for officers of the Section were presented and the election which followed placed W. C. White in office as Chairman of the Section and W. E. Keith was re-elected as Secretary.

The Fourth Annual Meeting of the **Upper New York Section** of the American Society for Engineering Education was held November 18–19, 1949, at the University of Rochester. Members of the Section were guests of the Eastman Kodak Company on three separately conducted tours. A dinner at Kodak Park was followed by brief talks by several key men of their organization. The Executive Committee accepted the invitation of the University of Buffalo to hold their next annual meeting there in the Fall of 1950. The Chairman of the General Session was H. W. Leet. A welcome was extended to the Section by Dr. D. W. Gilbert, Provost of the University of Rochester, and S. W. Barnes explained the building of the cyclotron at that institution.

At the drawing conference three papers were presented by H. G. Kinner, J. L. Hill, Jr., and H. L. Francis. F. H. Rhodes presented a paper at the English conference and M. J. Wantman presented informally the topic "Examinations and What They Measure" at the conference on Grading Methods.

The following officers were chosen for the ensuing year: Chairman, F. H. Thomas; Vice-Chairman, W. H. Allison; Secretary-Treasurer, A. D. Taylor. G. K. Palsgrove was re-elected as delegate to the National Council.

University Centers within Industry and Government: A New Frontier of Higher Education*

By A. H. HAUSRATH

Office of Naval Research, Department of the Navy
Washington, D. C.

A number of years ago one of the earlier proponents of continuing education for adults, Dorothy Canfield Fisher, wrote under the title "Learn or Perish." That statement was peculiarly prophetic of the vital part education now serves, and must continue to serve in our contemporary civilization. It appears more clearly now that the "learn or perish" alternative is significant both in the economic life of the individual, and in the destiny of nations.

No major nation today dares lag in the race in technology, and hence is spending unprecedented sums on research and development. Increasingly the emphasis on frontiers of knowledge requires ever higher levels of academic preparation and larger numbers of individuals trained to these levels.

The Ph.D. degree, previously the goal of the occasional person who aspired to a life of scholarship in a university, has now become the accepted minimum for entrance into the practical pursuits of industry and government in such fields as chemistry and physics. The master's degree may soon be as important in many of the engineering fields as the bachelor's degree has been. Everywhere the need for extending the period of formal training for those who are to be the leaders in technological pursuits is recognized as a necessity. The military security of nations and the economic security of individuals both require continuing and advanced education to protect and insure the future.

Phases of Advanced Education

The problem of advanced education has two important phases. The first phase is the period of full-time, resident study at an institution of higher education culminating in the highest terminal degree the individual can achieve before the economic pressures of life require him to seek remunerative employment. The level of this terminal degree varies for individuals in relationship to their financial resources, but not in relationship to their intellectual capacities. Scholarships and fellowships may help to broaden and extend the period of systematic residence study, but cannot be relied upon to bridge fully the chasm between resources of money and mentality. The inevitable result is that many who should continue to higher levels of training must leave the campus to engage in the work of the world. Until some means is found for such persons to continue their formal education *after entering upon employment*, we will continue to waste our most precious natural resource, latent human capacities. We must find ways to extend the period of full-time formal education for talented individuals.

The second phase of the problem of ad-

* Presented at the National Capital Section meeting, Johns Hopkins University, May 7, 1949.

vanced education is that of providing for continuing part-time education for employed workers. All professional pursuits now require life-long study to keep abreast of new developments and to grow in mastery of one's own field of knowledge. While this problem is not exclusively confined to professional pursuits, it certainly is of the highest order of importanee in such pursuits.

Continuing education has been a responsibility of the individual himself. It must continue to be. But it need not be his unaided responsibility. Just as each professional worker needs his own personal library, he also needs the greater resources of more systematic and extensive collections, and services that a modern library can render.

All true scholars, to the best of their opportunities, read intensively and study the literature of their own fields with great diligence. Independent study will always be the characteristic of the professional man. But, like personal libraries, independent study alone no longer suffices. Science and technology is moving forward at such a rapid pace that no one can read all the published literature appearing in his field. The scientific journals are not able to keep up with the flood of technical papers submitted for publication. One journal in one scientific field recently had an accumulation of more than 800 manuscripts awaiting an opportunity for publication. Merely to publish promptly all worthy scientific and technical papers would not solve the problem. Abstracts, bibliographies, library facilities are substantial aids to independent study, but do not fill the complete need.

Pacing the Frontiers

Conferences and correspondence with others who are actively engaged in the same and related fields of specialization, participation in scientific meetings, and visits to the laboratories of other investigators are highly important means of keeping abreast of new ideas, new approaches, and new knowledge, long before results appear in print. Such activities supplement the reading, study, and independent research of the scholar. Only after long years of such persistent efforts is one rewarded by an ability to evaluate and discriminate in his intellectual diet so that he can rely upon these means to keep informed on significant contributions. But this process is wasteful and many fall by the wayside. They never develop their full potential because their catch-as-can individual study is continually interrupted by other demands on their time.

Attendance at and participation in lectures, seminars, colloquia, symposia, and other informal gatherings whether with plain or fancy names, are valuable adjuncts in one's professional development.

But all this is not enough. What is needed, as a base for all continuation education, are systematic courses. They may be short, intensive, and concentrated as for refresher courses, or they may be developmental in nature and spread over a longer period. So far, no adequate substitute has been found for the imposed discipline of a systematic program of instruction requiring regular preparation and study, and making progress toward a desired goal; under the guidance of an able and respected leader; organized around a group of colleagues whose respect the individual wishes to retain; meeting on a regular schedule; and reaching a terminal point in a reasonable span of time.

This is the unique opportunity and responsibility of institutions of higher education to extend their mission of fostering learning, by providing continuation programs for employed workers. To do this would nurture rather than neglect our intellectual resources.

Industry-College Cooperation

A highly significant fact is that many educational institutions, particularly those in metropolitan areas, have developed extensive offerings of after-working-hours instruction. In some institutions enroll-

ment in courses scheduled so as to be accessible to people employed in earning a livilhood during the day, exceeds enrollment in courses offered for the convenience of full-time students. To service this need appears to be a new developing frontier of growing importance for institutions of higher education.

A number of engineering schools during the past decade have developed effective cooperative education programs with alternate periods of work in industry, and study in school. These programs meet one type of need.

Both the evening class programs and the cooperative plan require the student to come to the educational institution. This is highly desirable—for those who can arrange to attend classes at the university.

The present need is to extend the plan of *bringing the university to the student.* Extension centers are being set up "where the students are." At such centers fully accredited courses are offered under competent instructors. An increasing number of institutions are developing such extension centers in order to bring the university to the people who need it.

One type of Extension Center is proving particularly effective. That is the type where the Center is set up in cooperation with an employer, to make it serve the needs of those who are working for that employer.

University sponsored courses are being offered in many industrial plants and in several government establishments. The results are highly satisfactory—in competence of students enrolled, in numbers reached, in quality of work done, in adherence to academic standards, and in satisfaction of the university faculty, the employer, and the employee-students enrolled. Such courses offered at federal government laboratories in the Washington area enroll about 1000 at the present time, and the great majority are at the graduate level. Similar programs are in operation at Glenn L. Martin here in Baltimore; at Boeing in Seattle; at the Aluminum Company of America in Pittsburgh, Pa., and Massena, N. Y.; Dan River Mills, Danville, Va.; Allis-Chalmers in Milwaukee; at Westinghouse plants in New York City, Buffalo, Philadelphia, Pittsburgh; at the Naval Air Development Station, Johnsville, Pa.; at Wright-Patterson Air Force Base, Dayton; at the Naval Ordnance Test Station, China Lake, Calif.; at the Army Engineer Corps, Ft. Belvoir, Va.; at the Carnegie-Illinois Steel, Gary, Ind.; and at many other industrial plants and government laboratories. These programs are no fad. They are here to stay. They will continue to grow. More and more educational institutions will participate.

Another important phase of this problem is provision for thesis research to be carried on in the laboratories of the employer and under the guidance and supervision of the university in order to meet requirements for the Master's and Ph.D. degrees. This program is in operation at several federal laboratories, and a number of degrees conferred as a result. Time does not permit a detailed report here.

Survey of ONR and American Council

The Office of Naval Research under a contract with the American Council on Education is sponsoring an extensive research study of the whole problem of providing university sponsored courses and thesis research at federal laboratories. We think the results of these studies will be of widespread interest, and serve as a helpful guide in establishing new programs.

A very significant fact in the movement is that increasing numbers of private and public employers are recognizing an obligation on their part to assist technical employees in continuing their formal education. In the case of commercial concerns, this interest is born of cold facts of reason in operating at a higher profit rate for stockholders. Government agencies, research laboratories particularly, are making special efforts to provide such educational opportunities

for their technical staff members in the conviction that more creative and productive work results.

During the last two years, representatives of government agencies and private concerns have found that opportunity to continue their formal education is a much more effective inducement than higher salaries when interviewing the more able and promising younger engineers and scientists. It appears that this is a phenomenon of new vitality in the employment situation. Facilities for continued education of employed workers are rapidly becoming necessary in order for an employer to compete successfully in the market for the most able young men trained in technical fields. The day may not be far distant when educational programs in cooperation with recognized universities and professional schools will be a standard practice in industrial and in government establishments employing scientific personnel.

College Notes

A new five year curriculum leading to the degree Bachelor of Science in Architecture will be instituted at the **University of Colorado** in September, 1950, at the University of Colorado. This course of study will be in addition to the work in Architectural Engineering which was established 25 years ago and which now has an enrollment of 250 students. The new curriculum will emphasize structures, since the boldness in modern design requires an appreciation of both the aesthetic and engineering.

G. Leland Bach has been named the first Dean of the Graduate School of Industrial Administration, according to Dr. Robert E. Doherty, President of **Carnegie Institute of Technology.** The Graduate School was founded at Carnegie this year by a six-million-dollar gift from the W. L. and May T. Mellon Foundation.

Adoption of two new five-year educational programs by the **Lehigh University** faculty was announced by Dr. Martin D. Whitaker, president of the university. The first five-year curriculum will offer the degree of bachelor of science in mechanical engineering at the end of four years and that of bachelor of science in electrical engineering at the end of the fifth year. The second new curriculum approved will give a student the opportunity to receive the degree of bachelor of science in industrial engineering at the end of four years and that of bachelor of science in business administration at the end of the fifth year. In establishing the combined electrical and mechanical engineering five-year program, the educational policy committee of the faculty reported that the engineering work of electrical manufacturers and public utilities in the power field is almost equally electrical and mechanical.

Engineering Colleges and Industry

By J. H. LAMPE

Dean of Engineering, North Carolina State College

Classroom procedures, teaching methods in our basic and fundamental engineering subjects, English for engineers, and humanistic and social trends have long been favorite themes of the American Society for Engineering Education. Too often we are prone to think of the Society as having activities only in these fields. Within the Society, however, there has always been activity and interest between some of our members and men active in industry. The obvious desirability of team play between engineering educators and industry has become more and more evident, especially so in the last few years.

In 1946, immediately following the close of the World War II, engineering college enrollment reached its greatest peak. At the same time industry's release from war activities led to greater production of products for civilian use. This productivity in industry, spurred on by tremendous demand for products to be used in this country as well as in the world at large, reached an over-all peak where more than sixty million people worked. These two factors—exceedingly large engineering student enrollment and tremendous production on the part of industry—brought before the American Society for Engineering Education and industry a vital need for a better understanding of one another's problems. Cooperation is obviously needed in the years ahead to effectuate such plans. It is fitting and timely that Dean Freund, president of the American Society for Engineering Education, has urged the Society to forward a program of conferences and meetings, having as an objective team play between the American Society for Engineering Education and industry; in other words, partnership with industry. My paper will deal with this topic, and I shall attempt to point out our past situations, present developments, and ways and means of improving team play between industry and engineering education.

The American Society for Engineering Education has been most effective over the years in developing programs of study in the various fields of engineering education. Society committees under the chairmanship of, first, President Wickenden and later Dean Hammond have carefully considered, evaluated and correlated engineering programs at the college level. Of course the recommendations of these committees serve as milestones and lighthouses as we in engineering education move ahead with our curricula planning and our teaching so that our students will have the benefit of an effective engineering study and will be further encouraged by the provision of some broadening and liberal courses in the humanities and social sciences.

Educational Isolationism

Many members of the American Society for Engineering Education, however, do not have the opportunity to know the large industrial companies of the United States, nor do they have an opportunity to become acquainted with all the companies represented by the membership of the American Society for Engineering Education. Sometimes this

lack of opportunity is due to a geographic separation of great distance; sometimes it is due to the fact that engineering educators are located in a region which is primarily agricultural; sometimes, particularly in the past years, it is due to the fact that industry had to retract in the depression period; and sometimes, unfortunately, it has been due to the lack of interest of some of us in the engineering education field.

Some of us in engineering education are prone to be aloof from industries. We lose sight of the fact that if our engineering training is to be modern and of greatest value to our students, we must know through actual contact, as well as through reading, the day-by-day progress and development of industry. We cannot stay aloof from industry and depend alone on textbooks and course notes. We must continue to maintain a liaison with industry which will bring us knowledge of industrial research activity, industrial "know-how," and economic and industrial control adjustments. It is essential that engineering administrators and engineering teachers never forget that engineering is a practice and a profession.

A very large industrial company has found through years of operation that close cooperation with engineering colleges and engineering administrators is most helpful to industry. The American Society for Engineering Education has been fortunate in having such companies and their representatives join in the solution of the over-all problems to our mutual advantage. On the other hand, we, from time to time, contact or hear from other organizations who are not so engineering college-minded. Such organizations and individuals might be vaguely aware that there is a college of engineering nearby and once or twice a year contact the college and interview seniors in the hope of employing one or more.

If this is the total extent of the relationship of industry, or industrialists, with the engineering college, then an opportunity is being missed for cooperation with the college and students who want to know a great deal about the company's activities, operations, and products. It will aid the industrialist to have the engineering teachers and students know about his up-to-date manufacturing processes and forward-looking management-labor relations. Such liaison could not help but interest the better students and thus help the industrialists even though the attainment of new personnel is his only objective.

Need For Cooperation

In this day and age of adjustment of some of our fundamental concepts we realize that progress in science and technology is far ahead of that which has been made in our economic, social, and human relations. One thing we have learned, and probably through bitter experience in the past three years, is that we are no longer individualists or isolationists. At best, we are component parts in the developments of our community, nation, and world. If we are to make gains, plans must be made on an industrial and community basis dealing with this problem of educating young men for industry. The only proper approach is for the educators and the industrialists to join hands to develop a program for the best engineering training possible. Further, we must have full opportunity and mutual support for a continuous and cooperative training program for engineering teachers, whereby they will be briefed and will have an opportunity through personal experience to learn new and modern engineering design, processes, and economic development.

To aid such a correlation between engineering education and industry, the American Society for Engineering Education must reach and interest all industries both large and small. I believe that the Society has its greatest challenge and its best opportunity to serve the future young engineers by expand-

ing its work with small industries. There must be developed a mutual understanding as to the contributions that can be made by proper engineering in industry, government, the development of state highways, and in the field of Sanitary Engineering. The southeastern region of the United States has made much progress in this direction but much more must be done.

Growth of Small Industry

We are in a land where large industries are few in number, although their ranks are increasing each year. Our great strength and opportunity in the southeast lie in our small industries. Many of these organizations were established during the last World War and have continued to operate here under favorable conditions. Representatives from every engineering school here can point with pride to the establishment of more and more small industries in his state in the last three years. Many of these newly established small industries are operated by local capital and management. Others are small units of some larger manufacturing corporation. It is our opportunity to have the organizers and administrators of such small units to know about our engineering facilities and the training and research possibilities that we have available, and to ask them to join us in planning and advising as to engineering education and the training of engineering students at our colleges. I am sure that among other things such a policy will make for openings for engineering graduates and the employment of more of our own graduates here in our southern industries.

I refer you to a paper on "Supply and Demand of Technical Graduates of North Carolina Industry" by W. S. Fink. This report deals primarily with ceramic engineering activities. It denotes that in the past about five-sixths of the ceramic engineers trained in North Carolina accepted positions in other states. In the same period, from 1930 to 1946, the demand for ceramic engineers in North Carolina was far exceeded by the supply as represented by the number of engineers graduating in the State. I am happy to report that during the last two years more than sixty per cent of our graduates accepted employment in the ceramic industry of North Carolina. This has been brought about by closer relationship between the ceramic industry and the members of the faculty of our Ceramic Engineering Department. This mutual acquaintanceship, among other things, has supported ceramic conferences at North Carolina State College. Thus the ceramic industry has come to know our Ceramic Engineering Department and we have gotten to know the men working in the State industry.

Our engineering teachers have visited the ceramic industries on many occasions and have undertaken problems with mutual interest. The concrete evidence of this mutual work and understanding has been the employment of more of our engineering graduates and the financial support of engineering research projects.

We propose to expand this type of liaison work with industries in North Carolina in all fields of engineering. I urge you to increase your efforts in this activity for the betterment of engineering education in your own community and state. In such activity, industrialists and educators alike have responsibilities. As I have pointed out previously, there must be a great deal of mutual opportunity and action between the two groups. Initiative must be taken by both sides, correlated, it is hoped, with some endeavor started by the industrialists and with other endeavors, which are unique to education, activated by the engineering teacher.

Industry's Part

I am now taking the liberty to suggest some activity that might be initiated by the two groups acting individually. It might be well pointed out that several of

these activities are now being carried on in excellent fashion by some of us.

A. What industry might do.

1. Pass on to the engineering college administrators written suggestions that would assist the colleges in preparing their curricula.
2. Acquaint both faculty and students with progress being made through specially prepared periodicals, booklets, and reports.
3. Provide summer employment for the engineering college professors with the dual purpose of giving the professors an eye-view of the work being done and also to indoctrinate him as to the company's engineering and production activities; thus, the professor would better know what was expected of an engineering graduate entering the company's employment.
4. Write reports for college publications. By this I do not mean material for paid advertisements. A complete write-up of the company's development, management-labor activities, engineering and production accomplishments, and educational policy would be accepted and printed verbatim by most student editors of college publications.
5. Send high-level and well qualified personnel to the engineering colleges for interviewing purposes. Such personnel would make every effort to become better acquainted with the faculty as well as the students to be interviewed. At the present time, this is the best opportunity for representatives of industry to become acquainted with engineering educators.
6. Develop an employment policy which will provide ways and means of employing engineering students for the summer period between their junior and senior year. If possible, this short-term employment for the summer period should be extended to students between their sophomore and junior year. Employment during the summer, before graduation, enables the students to become better acquainted with company activity, company relations, and company policy. If he, upon graduation, accepts employment with the company, then the industrialist can rest assured that in most cases he has a permanent employee.

Responsibilities of the Colleges

B. What the engineering college educator can do to serve industry.

1. Offer new courses and curricula in in cooperation with industry. Such a program might be a regular undergraduate four-year activity, or it might take the form of specialized studies and research in the graduate school. A further possibility is the offering of short courses on some particular subject of wide interest to industry. These short courses might be from one day to three months. Another urgent need in our region, and one of growing importance, is the development of a technical institute program, largely of a terminal nature, which will train young people and make them adaptable for important positions in industry. I am told for every qualified engineer in industry, there is a place for at least five graduates of technical institutes.
2. Develop and give more attention to cooperative programs of education whereby a student spends a fixed period in college of approximately three months, then works in industry three months, then returns to college, etc., until he graduates.
3. Develop an effective and dynamic extension program which includes in-service training and adult education.

4. Encourage and support engineering research. The college budget for this service should be adequate to employ full-time personnel to carry out minor consulting services for small industries of the state. An engineering research budget should support theoretical as well as applied endeavors. It should cooperate closely with industry, especially on sponsored projects, but only insofar as such projects are acceptable and are supplementary to an engineering education program.
5. Require summer employment for engineering students as part of the work for the baccalaureate degree.
6. Require that every engineering student make extensive inspection trips to various industrial plants in an effort to give him some appreciation of the practical aspects of his chosen field.
7. Encourage the teaching staff to accept summer employment in industry in order to become better acquainted with modern concepts and new processes, as well as with the men and women in our industrial life.
8. Periodically issue a publication describing the engineering college's activity, especially those activities which will be of interest to small industry.

From an address by Mr. James D. Mooney, president of Willys-Overland Motors, entitled "Wide Training for Today's Engineer" I quote the following excerpt:

> "The first of the essentials is the ability to express himself fluently, clearly, logically in good English, both in written and spoken word. . . .
>
> A thorough study of history may seem to a student of science as a wholly irrelevant matter, yet I venture to say that from a cultural point of view in rounding out a man's perspective and helping him to understand the world in which he lives, the world in which he comes from, and the world to which he is moving, no study could be more effective, particularly if the history he is taught is based on the economic forces which create the tide underlying almost all of the great movements in history. . . .
>
> A third essential for today's job is a basic grounding in the principles of economics. . . .
>
> A fourth essential, and beyond these studies, to be fully equipped to lead, the engineer must recognize moral and spiritual values in life in order to have a sympathetic understanding of his fellowmen."

Mr. Mooney is urging us, the educators, to see that an engineering college graduate is not just a technically qualified individual but that he must also be prepared to assume a wider field of activity—broader socially, politically, economically, and morally. Such a program under the guidance of competent engineering educators is a *must* for our modern engineering college.

Conclusions

I have named some of the important projects, aims, and scopes which will help to further and accentuate cooperation between engineering colleges and people of industry. I know that there are many other possible endeavors to help with team play. Many of the engineering teachers and administrators belong to professional and technical societies where they can get acquainted with men of industry as they talk about technical activities and industrial progress. In these groups, however, we are usually split off as civil engineers, electrical engineers, mechanical engineers, etc. There is no over-all technical society which includes in its membership all kinds of engineers other than the American Society for Engineering Education.

I hope that the American industrialist and business man will give serious thought to joining the American Society for Engineering Education, for in its meetings and its publications he has a real opportunity to get to know all engineer-

ing educators, to take part in their discussions, and to work with them in a mutual development of a training program for American youth. I believe the American Society for Engineering Education has before it one of its greatest opportunities by giving consideration to the human and industrial aspects of our society, as well as to pedagogical problems. In this endeavor we should promote joint conferences and develop plans of action for all engineers and all industrialists in the socially minded engineering and industrial life of today.

Let us go forward partners in industry!

In the News

A selected bibliography of civil engineering subjects listing more than 225 titles grouped under 8 headings has just been published by the **Engineers' Council for Professional Development**, 29 W. 39th St., New York, N. Y. The list has been prepared as an aid to the engineer who plans to continue his studies in civil engineering or to build a private library in this field. The titles were selected by more than 100 engineering teachers and professional engineers who cooperated with the ECPD Committee on Professional Training. Most of the books listed are of the college grade. Each listing is annotated to indicate the nature and depth of the subject matter. The price is 25 cents.

Cooperative Engineering Education at the Graduate Level (From the Viewpoint of the Graduate School)[1]

By RAYMOND E. KIRK

Dean of the Graduate School, Polytechnic Institute of Brooklyn

The great desirability of graduate training for selected persons is now completely recognized throughout American industry. We are to discuss here that portion of the general problem of graduate school training which deals with cooperative endeavors, utilizing the staff and facilities of industrial organizations and of graduate universities in order to promote "in service" training of persons employed in industry. Each one of us here has seen a tremendous change with respect to graduate instruction in engineering. Not too long ago the person with advanced training in engineering was suspected by industry and often by the universities. It was suspected, among other things, that his additional time in the university had been because of inability to meet, immediately upon receipt of the baccalaureate degree in engineering, the requirements of American industry. I need not relate here the many factors that have operated to change this attitude and to bring about the present appreciation by American industry of the role of the graduate school in training scientists and engineers to meet the demands of modern industry.

[1] Presented before a joint meeting of the Graduate Division and the Cooperative Engineering Division at the 57th Annual Meeting of the A.S.E.E., Troy, N. Y., June 22, 1949.

Objectives and Policies of Graduate School

Any such discussion as this must obviously start, if I am to represent fairly the viewpoint of the graduate school, with a brief discussion of the objectives and problems of the graduate school. These are especially important at this time in the consideration of admission to graduate programs in science and engineering.

There seems to be general agreement that careful selection of graduate students is highly desirable in order that those persons admitted be capable and prepared to profit from the fundamental courses now usual in such programs. There seems also to be general agreement that undergraduate records alone do not constitute a good single criterion for admission. In the sciences there has come to be extensive use of the graduate record examination. This has proven to be an excellent way by which success in graduate programs in science can be predicted.

There does not seem to be general agreement as yet regarding additional criteria that can be used in the prediction of success in graduate programs in engineering, especially for men without industrial experience. Fortunately, a very considerable number of the applicants for admission to graduate work in engineering have had some industrial experience. It is being discovered in connection with these men that the considered

opinion of their superior officers is often of great value in connection with selection for admission. This means that superior officers must take seriously requests for recommendations.

One graduate school uses these phrases. "Applications for admission should be supported by letters of recommendation from persons well acquainted with the applicant and qualified to testify to his aptitudes for graduate study and research." It should be noted that the emphasis is here placed upon aptitudes as well as upon abilities and that the person writing such letters of recommendation soon becomes respected for his opinion. It inevitably follows that persons who write enthusiastic letters of recommendation for every one of their staff are ticketed in the Admissions Office of the graduate school as poor sources of recommendations. While it is highly desirable to admit to the graduate school only those persons who have high moral characters and outstanding personalities, these very desirable qualities do not serve as adequate substitutes for aptitude for engineering study at the graduate level and ability to undergo rigorous programs of study.

It has also been discovered that reprints of published articles, copies of scientific patents, and photostats of professional reports are a great help in establishing superior attainments for graduate study and research. Most graduate schools offering programs in engineering welcome such evidences of the ability of students to participate in and profit by advanced instruction and research.

Some graduate schools have developed programs where specific courses, often of descriptive sort, are made available for students who are not clearly seen to be fully qualified for degree programs. This device is sometimes extended in order to permit such persons to attempt one or more fundamental courses on a trial basis. This enables additional evidence to be accumulated before a final decision is made about admission to degree programs.

Maintenance of Standards

The graduate schools of engineering are today confronted with a grave problem in the maintenance of standards for graduate courses and for degree programs because of greatly increased enrollments. These increased enrollments are related to the vastly increased demand for men with advanced degrees, as well as to the greater opportunities for graduate instruction because of the financial assistance available under the government programs for veterans. Consequently, the graduate school of engineering must check, even more carefully than before, the aptitude of those admitted to courses and to degree programs and upon the procedures and personnel of the graduate school. It is the essence of graduate instruction that it should center around the abilities, interests, and enthusiasms of individual professors. The administrative problems of the graduate school are those related to protecting these gifted members of the staff from unduly large classes and from inadequately trained students. It is my own conviction that these responsibilities can best be discharged by continued participation of the professorial staff and of the individual departments in the administration of the admissions program. It would seem extremely unfortunate if any department of instruction should be forced to accept responsibilities for programs and students without having shared in establishing the programs and in selecting the students.

There seems to be, as of 1949, general agreement that there should be a careful planned balance between formal training in courses, individual laboratory work, and small seminars. It seems also to be generally agreed that in the graduate training of engineers there should be emphasis upon basic aspects rather than upon descriptive matter. This becomes especially important when the registrants come from industrial employment, and is stressed by prospective employers.

Graduate Degrees

There seems to be considerable difference in practice at the present time with respect to the significance of the several graduate degrees in programs of graduate instruction. Certain universities seem to employ the program leading to the Master's degree as a period of time in which additional material is presented which concerns itself with industrial technology rather than with the fundamentals of engineering science. These fundamentals are reserved for persons who enter programs leading to the Doctor's degree. Other universities have taken the position that the program leading to the Master's degree is one which should concern itself with the critical understanding of fundamentals. It is interesting to note that this attitude would give real meaning to the word "Master." The program for the Doctor's degree is considered as one which goes on from this critical understanding of fundamentals to a program of studies which broadens this understanding, but at the same time utilizes the training in connection with careful preparation for a life time of productive research. In still other universities, some portion of the time devoted to the Master's program is used for a fundamental investigation. This last plan seems especially appropriate in light of the much larger number of Master's degrees given in engineering education at the present time and in light of the overwhelming evidence that the great contribution of the post-graduate engineer is in productive research, both pure and applied.

Graduate Research

I am certain that each one of us present here realizes the great problem involved in the extensive program of dissertation research that has been hinted at in the preceding paragraph. Research in fundamentals of engineering makes tremendous demands on both staff and equipment. However, if we are to meet the expectations of our friends in industry, we must supply them with engineers holding graduate degrees who are prepared to rapidly take their places in the well developed research programs of modern industry. If we do not do this, our claims for graduate training will soon prove themselves unfounded. It is not the purpose of this discussion to indicate the solution of this problem. It is well, however, to recognize its existence whenever and wherever graduate training in engineering is in discussion. It is, of course, closely related with the over-all problem of the engineering colleges; the problem which I think is the greatest of all; the problem of a well qualified *teaching* staff. Only if the engineering colleges of our universities are staffed by persons interested in research and able to supervise research will we have the strong *teaching* that is now demanded by industry. Only then will we be able to continue to send out well qualified Bachelor's men as well as men trained to higher levels.

Cooperation with Industry

The cooperation of industry in meeting the objectives and problems of the graduate school is both feasible and practical. I am certain that it will be of great value, especially in the following respects.

First: As has been intimated, industry has cooperated and should continue to cooperate in the selection of students particularly well qualified to profit by continued training in the fundamental aspects of engineering science. It is to be hoped that each of our friends from industry will take a vigorous personal interest in the admissions problems of graduate schools of engineering. It is to be hoped that each individual will continue to suggest the benefits of graduate training to outstanding young men now entering industry who will have one or more years of "expectancy" under the Veterans Administration. They will be very much better graduate students after they have seen how the research organizations in industry actually function.

Second: The graduate school of engineering will always welcome carefully considered suggestions regarding subject matter courses of particular interest to certain industrial groups. It has been my own observation that these suggestions always stress the importance of fundamentals of engineering science. University men need not fear any sacrifice of fundamentals when they follow the suggestions of our professional colleagues from industrial research organizations.

Third: Helpful cooperation can very often be had in connection with problems suitable for graduate dissertations. Here, too, the experienced engineer from industry will see that the best way to avoid entanglements with the patent department is to contemplate an investigation of very fundamental sort. The duty of the graduate school involves prompt and complete publication. Thus all interests are best served by investigations of fundamental character. The graduate school should never become a low-grade patent mill!

There are many ways in which cooperation with industry has been carried out in various graduate schools of engineering. The one which comes the closest to the normal situation from the standpoint of the university is where men from industry are given leave to carry on full time study programs. In some instances industry selects particularly valuable and promising members of their staff and allows them full-time study on leave for nine months with or without special subsistance pay. This is often accomplished by some procedure which permits the employees to retain seniority standing and retirement allowances from the company in question. Very often the student is paid a salary directly from the company. This salary may or may not include special allowances for tuition. In other instances industrial companies have given scholarships to a designated university to be held in a certain field of specialization and with the understanding that the company may nominate promising young men for consideration for the fellowship. In such instances funds are given directly to the university to cover stipends, tuition, and fees.

An extension of the same scholarship plan often allows the university to select honor students and retain them for an additional year of advanced training. In these instances there is usually no commitment on the part of the student with respect to employment. In many instances, however, the personnel officers of the company find that the graduate student is anxious to be considered for employment in the laboratories of the sponsor. While the number of persons who can be trained by these arrangements will be necessarily limited, it should be realized that young men of outstanding ability can be developed very rapidly for responsible posts in the research organization of the sponsoring company. It has, I believe, been the experience of the graduate schools of engineering that sponsoring companies have at all times stressed the importance of fundamental training as against training in technology. It is a manifest waste of time for students to study at the university the aspects of industry that are best appreciated while on the job.

Despite the many advantages seen by the graduate school in the plan whereby industry sends to the university full time students, it should be recognized that much of the cooperation known to be so desirable will of necessity involve part-time students. Here the burden of developing new attitudes and techniques on the part of the teaching staff rests primarily upon the university. Those graduate schools of engineering who have undertaken such cooperation will all testify to the enthusiastic cooperation of employing organizations. They can also testify to the great stimulus given the teacher who discusses fundamentals of engineering science with classes made up largely of outstanding young engineers actively working in industry.

One plan which has been found to be satisfactory is where the graduate school plans a group of courses on company

premises, but taught by the regular graduate school staff. This is especially desirable when at some later date the same students are to enter degree programs in the university. These courses have in many cases been given entirely on company time. In other instances they have been given partly on company time. In still others they have been given in evening hours outside of company time but with company recognition and encouragement. In a great many instances this recognition and encouragement is extended to complete or partial participation in meeting the financial burdens of such enrollment. It would seem from experience in this field that the details of such arrangements might best be worked out in conference in order that special local conditions can be recognized.

Company Incentives

Industrial organizations located within commuting distance of graduate schools that give part-time graduate work on the campus often release employees at whatever hours are found necessary to permit needed travel. In certain instances graduate courses have been given in the late afternoon hours and industries have cooperated in releasing registrants early for travel time. The amount of released time varies greatly with the necessities of the situation. There are instances where employees have been given leave for half a day each week where long travel was necessary. There are innumerable instances where industrial organizations have permitted shorter periods of time in order that their employees might attend classes in evening hours.

The graduate schools of engineering that offer evening school courses and programs report that a considerable number of companies have plans well worked out providing financial assistance. The most familiar scheme is one where the student pays the tuition himself and the company repays him for all or part of the fees when satisfactory grades have been earned in the courses. In my own experience this has seemed to be a very satisfactory arrangement since it places the responsibility for accomplishment directly upon the student.

Many industrial organizations have found that additional incentive can be given by appropriate publicity when their employees receive academic honors. House organs often report the attainment of degrees in part-time study, the publication of papers on fundamental topics written in cooperation with a professor, and elections to Sigma Xi. Such procedures are especially serviceable in calling to the attention of younger men of the organization the opportunities for further training by means of part-time graduate study.

Teaching Personnel

Many graduate schools of engineering, especially those located in the Metropolitan areas, have found it possible to cooperate with industry with respect to teaching personnel. Every company has research men who make ideal teachers. Many benefits flow to the company when one of their research men is selected to teach special graduate courses. The continued emphasis upon fundamental principles that has come to be so usual in graduate courses in engineering enables the part-time teacher to review subject matter and to extend and perfect his mastery of fundamental principles. The most usual instances of company teachers seem to be those where the classes are given out of company time. Arrangements are usually made directly between the university and the part-time teacher, but with the knowledge and approval of the employing organization. In certain cases, especially where company employees make up part or all of the class, company time has been used in whole or in part for such teaching.

When teachers are recruited from industry there is the added advantage that the faculty and the student body of graduate schools of engineering come to

know first hand the views and attitudes of the leaders in industrial research. The university can and should recognize the qualified and experienced graduate teacher by the use of appropriate titles. Several universities use the title of "Adjunct Professor" to indicate that the teacher from industry has met the same criteria with respect to professional reputation and teaching ability that are usual for those who hold chairs in the university. In many instances, cooperation with respect to graduate dissertation comes easily of such associations. It is, of course, evident that natural cooperation is always to be preferred to formalized relationships.

Many universities are arranging special seminars and symposia designed to cover special fields of particular interest, both to university personnel and to industry personnel. In most instances, the graduate schools have taken the lead in arranging such meetings and even in financing them. It seems that industry might well consider using this plan for obtaining for its members the stimulus of round table discussion, where the participants are leaders in the field in question. This can be done by releasing selected staff members for attendance at seminars or symposiums already arranged, as well as by cooperation in financing and arranging such meetings in fields not already covered. In the instances referred to it has been very usual to draw the lecturers from the research organizations of industry, as well as from universities. Such conferences are also extremely stimulating to the full-time graduate teachers and indirectly to all graduate students.

Exchange of Personnel

A more extensive interchange of personnel between industrial organizations and the graduate school would be helpful and beneficial to both groups. The well qualified graduate teacher can bring new viewpoints to the problems of industry. Experienced research men from industry can bring new illustrations and new applications to the subject matter of graduate courses and to the discussions of departmental and school staffs. It seems that this mode of cooperation has not been as widely employed as it might have been. It is hoped that the procedures involved can be carefully studied and such interchange of personnel encouraged. It seems doubtful whether additional organization is needed in order to bring this about. Perhaps it would be best achieved by individual arrangements on the part of each company and each graduate school.

Graduate schools of engineering have long recognized the importance of industrial experience for their teachers. Many schools include it as a requirement for appointment and for advancement. Nevertheless, the current grave shortage of teachers has made it very difficult to carry through such policies and still staff the universities with well qualified teachers. Many industrial organizations have been of great assistance to the university by providing summer employment for younger teachers. It is to be hoped that additional companies will join the outstanding companies who have already perfected plans of this sort. There are many brilliant young assistant professors who can contribute to the solution of the problems in research and development during a summer vacation. In most instances these young men will also come to serve as liaison officers between the company and the university.

A particularly heavy responsibility in this matter rests upon the department heads who recommend young men for summer employment. An industrial organization has a right to expect that there will be very careful selection of the men who are to be given such opportunities. They should be young men who have already had advanced training in their special field. They should be young men who have already shown promise as "self starters" in research. Recommendations should never be made on the

basis that the young man needs a summer job.

It is desired to recognize that a young teacher with active research experience both in industry and in the university becomes a tremendous asset in the training of graduate students who are then to enter research and development groups. It seems likely that under present circumstances many of our ablest young teachers must rely upon summer employment if they are to rapidly acquire an intimate knowledge of the methods, attitudes, and procedures of industrial research organizations. The advantages are both technical and non-technical. Perhaps some research engineers from industry would be much surprised to learn the extremely sophomoric ideas about company attitudes that persist in graduate schools. The young engineers enrolled in our graduate schools should be taught by teachers who know first hand the "ins and outs" of the industrial organizations employing men with advanced degrees in engineering. Here all companies employing engineers may contribute to good public relations as well as to the preliminary training of prospective research workers.

The graduate schools of engineering are happy to acknowledge the support that industry has already given to their programs of advanced instruction and research. This assistance has been extremely helpful. It includes a considerable number of research grants, a considerable number of research fellowships and many instances of magnificent gifts of specialized equipment. Nearly all the outstanding companies in the fields allow generous educational discounts. The teachers of graduate students in engineering have found their colleagues in industry to be extremely interested in the plans, the procedures and the problems of graduate instruction. The continuing advice and counsel of all leaders in industrial organizations is sought and greatly appreciated. We trust that we will not seem ungracious if we ask for greater support, for more counsel, and for continuing appreciation when it is deserved.

Industry-College Relations: "The Role of the Engineering Educator" [1]

By RAYMOND WALTERS

President, University of Cincinnati

A few preliminary references to industrial conditions in Great Britain will, I believe, prove pertinent for our discussion of American conditions and of the topic "Industry-College Relations."

Conditions in Great Britain

Item 1. Unless a prior General Election should change the decision, the British Labor Government will make effective in 1950 the nationalization of Britain's iron and steel industry which was recently voted by the House of Commons. Such nationalization would fulfill the campaign pledge of the Labor Party preceding the 1945 General Election as follows:

"Private monopoly has maintained high prices and kept inefficient high-cost plants in existence. Only if public ownership replaces private monopoly can an industry become efficient." [2]

Sir Stafford Cripps seems not to be in complete agreement with his Party's "only" declaration. Upon his invitation, management and labor representatives of the American private ownership system have been conferring with British management and labor representatives for the purpose of improving British methods of mass production in industry.

Great Britain has long had brilliant scientists, and since 1916 has fostered a Government department to "promote and organize scientific research with a view especially to its application in trade and industry." [3] Why then should there be less efficient production in the mother country of the industrial revolution as compared with the daughter country across the Atlantic?

An answer is suggested by *Item 2.* At the recent convocation of the Massachusetts Institute of Technology, Winston Churchill said:

"We have suffered in Great Britain by the lack of colleges of university rank in which engineering and the allied subjects are taught. Industrial production depends on technology and it is because the Americans, like the prewar Germans, have realized this and created institutions for the advanced training of large numbers of high-grade engineers to translate the advances of pure science into industrial technique, that their output per head and consequent standard of life are so high." [4]

Mr. Churchill's diagnosis is in fact a pungent paraphrase of the statement in a communication of a British Parliamentary Committee:

"Britain possesses pure scientists on the one hand and craftsmen and technicians on the other unsurpassed by any other country, but the same is not true of professional engineers. The outstanding industrial advance in the United States of America, in

[1] Presented at the General Session of the Annual Meeting of the A.S.E.E., Troy, N. Y., June 24, 1949.

[2] English-Speaking Union *Bulletin*, Spring 1949.

[3] Article by W. R. Woolrich, *Journal of Engineering Education*, Vol. 39, No. 2, October, 1948.

[4] *New York Times*, April 1, 1949.

Germany and in some other countries is mainly due to the absorption by their industries of large numbers of men with high educational qualifications." [5]

American industrialists familiar with conditions in Great Britain have told me they concur that a high measure of credit for American industrial efficiency rightly goes to American technological education for precisely the reason Mr. Churchill and the Parliamentary Committee gave—it trains graduates to translate the advances of pure science into industrial techniques.

It is only fair, along with glowing words about technological education, to quote the tribute to those invaluable springs of fundamental research and training—the university graduate schools—as paid by members of the wartime Congress: "The nation's universities," declared a subcommittee of the House of Representatives, "before and during the war have distinguished themselves for their work in basic research." [6]

Fairness also demands that due credit be given American workmen for their acceptance of technological advances. I quote words recently spoken in a British broadcasting address by Paul Bareau:

"The productivity of industrial labor in Europe is about a quarter of what it is in the United States. It takes four Europeans to produce what one American produces. The explanation? It is quite simple: each American has that much more horsepower, that much more machine behind him. The American worker welcomes the machine which does the work for him and which has raised his wages to the highest level to be found anywhere in the world." [7]

Since Mr. Churchill and the Parliamentary Committee referred to the provision for technological education made by the prewar Germans, it is appropriate to compare the basis for such provision in Germany and in the United States. Hitler's Nazi regime set up technological training with a prescribed functional relationship between faculties of Reich institutes throughout Germany and the military government at Berlin. The institute faculties were to train students for military objectives: they were to be "true German storm troopers of science" [8] in directing research for military objectives.

Thanks to the boon of time provided by Britain's "blood, sweat and tears" resistance, the United States was able to catch up with and then to surpass Nazi technological efficiency as applied to military objectives.

The point I would make is that America's prodigious achievement was based not upon command but upon cooperation. It represented our reply to the taunt that, in matters of might and in times of war, democracy would inevitably be inferior to dictatorship.

In dealing with the topic of industry-college relations, we of American technological education may acknowledge with gratitude the tribute Mr. Churchill so generously and eloquently uttered. We may wear the rose he pinned upon us, if we remember the saying that flattery won't hurt you if you don't inhale!

Modestly therefore let us consider aspects of industry-college relations which have been sound and helpful and then aspects in which there remain shortcomings.

Beneficial Relationships

The aspects which I suggest as sound and helpful are two: Independence and interdependence.

1. *Independence.* In the United States we have had no domination by government, no Minister of Education who, in the European tradition, could take out his watch and declare: "It is ten minutes past eleven o'clock. At this hour in

[5] Quoted by Dean W. R. Woolrich, University of Texas, address, A.S.E.E. Meeting, June 23, 1948.

[6] Quoted in *Science the Endless Frontier*, Vannevar Bush.

[7] "How Dares Europe?", Paul Bareau, *The Listener*, London, May 26, 1949.

[8] Dr. Stork, director of the Reich Institute of Physical Engineering, quoted in *Science*, November 21, 1941.

every school room of the empire the subject being taught is history!"

As to technological education it may be said also that we have no domination by industry. Our programs of research and of teaching have been drawn up by our faculties without dictation and, in the vast majority of institutions, without reference to specialized industries. Happily this principle of educational freedom is accepted and championed by industrial executives as being both right and advantageous.

In appraising undergraduate curricula, the Engineers' Council for Professional Development has applied qualitative and quantitative criteria without Procrustean bed regulations. Technological schools have been able to go their own way, to develop new ideas and programs. The test has been the pragmatic one: Have the ideas proved to be sound? Do the programs work?

To educational independence we owe the individualism and initiative in our graduates which is the very fount of the originality, the resourcefulness of American technology.

2. *Interdependence.* Characteristic of the American campus is the willingness to play a team game. When students go out after graduation to industrial shop or office, they continue this trait. At the executive stage they confer; they come to a joint decision; they combine to put the job through. And, in a degree not equalled in other lands, as alumni they keep in touch with the faculty members of their Alma Mater; they confer with them; they act as liaison officers between educational theory and industrial practice.

This relationship is notably effective in respect to research. There are more than 3000 industrial research laboratories in the industries of the United States[9] which draw a yearly stream of masters and doctors in scientific fields from the graduate departments of universities and technological schools. These research men keep in touch with their former teachers—to the profit of themselves and their teachers. Interchange of ideas and programs proceeds constantly in the pages of the scientific and technical journals to which educators and professional research workers contribute. Thus informally and formally the fruits of scientific inquiry in fields of fundamental research become available for technological research and industrial utilization.

[9] Article, William C. Harnor, *Science*, September 7, 1945.

Illustrations of Cooperation

Since generalizations tend to pall, I propose to enliven, by means of specific illustrations, two case studies of actual industry-college relations. The first exemplifies what education is doing; the second, what industry is offering.

As to the educational institution chosen as illustrative I shall mystify you by calling it "Institution C."

The Cooperative System. Institution C has proceeded upon the doctrine that a good system of technological training (not the only way but a valuable way) is provided by active and sustained cooperation between education and industry. There is no necessity, in any engineering assemblage, to dilate upon the historic fact that this doctrine was initiated as educational practice by the late Dean Herman Schneider in 1906.

The heart of the doctrine is literal following of the term cooperative. The engineering educator cooperates with the practicing engineer or industrialist or business man in the education of the student; each, in his sphere, accepts a vital and responsible share.

The cooperative system has been defined by the cooperative institutions holding A.S.E.E. membership as an arrangement by which students alternate periods of attendance at school or college with periods of employment in industry or business, such employment constituting

a regular, continuing and essential element in the educational process.[10]

At our typical Institution C, the teacher has the leading role as the expounder of educational content: he presents content in the classroom, he demonstrates it in the campus laboratories. Theory comes first, both as to time order and as to emphasis.

To tie in theory and practice, to collaborate with the practicing engineer or industrialist or business man when the student goes to factory, field or office becomes the role of the engineering educator whom Institution C designates as the coordinator. The coordinator places the student in his job, follows his progress and keeps him in touch with the campus.

What do engineering educators at Institution C say about the cooperative system after more than four decades? They say that it is a grand adventure in teaching; that it enables the coop student to develop in normal times the qualities which World War II supplied the veteran student: maturity and purpose.

What do engineering and industrial participants in the cooperative system say? Here is the comment of the head of a cooperating company, Frederick V. Geier, President of the Cincinnati Milling Machine Company:

> "In every rank and field of endeavor . . . industry today enjoys the outstanding service and able leadership of many men whose capabilities directly reflect the basic principle of the cooperative system." [11]

For promoting team work between education and industry, the cooperative system is acclaimed as unexcelled by both partners in this stirring enterprise. At Institution C, the system has also proved highly effective in the College of Business Administration and the College of Applied Arts.

Faculty-Employer Relations. At Institution C, engineering educators take the initiative in contacts with industry such as the following:

Coordinators call upon industrial executives in the routine of their visits at factories and offices to confer with cooperative students.

Teachers conduct inspection trips to local industrial plants for students on the campus.

Faculty members give lectures before industrial groups in the city and surrounding area.

Faculty members participate in programs of the local Engineering Society and local branches of national societies.

Thanks to the initiative of the Coordination Department, certain industries are financing freshman scholarships which cover the tuition and living expenses of cooperative students for their first year.

Relations at the Executive Level. Institution C sponsors each year a series of ten lectures by national authorities in economics, business, finance, labor relations and engineering, delivered before the Business and Professional Men's Group, limited to 400 members. In the personnel of a recent group were included 64 corporation or company presidents and general managers, 42 vice-presidents, 26 secretary-treasurers, 44 department executives, 27 superintendents, 22 executive assistants and 36 engineers. A local newspaper editorially described these forum meetings as "a notable addition to the intellectual life of the community."

Of interest to local executives are numerous courses given in the Evening College. Younger executives attend as students. Practicing engineers, architects and business officials of the community serve as part-time teachers and lecturers.

Local executives frequently address the student chapters of national engineering societies.

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[10] Abbreviated definition, Statement, *Journal of Engineering Education*, Vol. 37, No. 2, October 1946.

[11] *Four Decades of the Cooperative System, 1906–1946*, University of Cincinnati, 1946.

Institutional-Industrial Relations. To meet the needs of industry in respect to industrial health and industrial medicine, Institution C provides, in the regular College of Medicine curriculum, for courses, seminars and research training specifically related to industry; and, for those desiring to specialize, it provides a three-year post-graduate training program in industrial medicine.

Institution C supplies industry with shop management, foreman training and similar instruction under the Smith-Hughes Act.

Laboratory facilities and services of faculty members are made available to industrialists on a consultant basis.

A gage laboratory is maintained on the campus for the benefit of local machine tool manufacturers.

Certain radio programs of the institution are directed toward industry.

The Student Speakers Bureau supplies capable undergraduates for specialized talks before shop foremen.

The cooperative students conduct an annual Coop Day exhibit for which local industrialists receive special invitations.

The Department of Coordination and Placement serves employers in the supply of graduates, part-time students and coop students.

Financial Aid from Industry. Institution C, faced with financial difficulties during World War II because men students left for the Armed Forces, appealed to local industries and business concerns. Contributions totalling $400,000 during one year and $200,000 during the second year tided the institution over until the post-war flow to the campus of veteran students.

At present Institution C receives moderate contributions annually from local companies which thereby recognize the practical advantage of having available a steady supply of graduates in technology, applied arts and business.

The foregoing are illustrative activities; they show how one American institution relates its educational offerings to industrial needs. You in this assemblage could cite a host of other ways and means as exemplified in your institutions.

How industry can relate its plans to technological education is demonstrated by an enterprising group of American industrialists. The Diesel Engine Manufacturers Association, at the close of World War II, set up a five-year program to develop cooperation, with the following objectives:

> "1. To help all engineering schools obtain adequate laboratory equipment.
> "2. To foster the use of this equipment intelligently and efficiently, through improved layout, additional instrumentation, and better laboratory procedures.
> "3. To sponsor improved diesel engine text material by issuing pamphlets on special subjects.
> "4. To assist the improvement of laboratory and lecture courses.
> "5. To encourage those schools which offer diesel graduate studies to have their students do thesis work that is valuable and interesting.
> "6. To help professors improve themselves by means of short conferences on the latest technical developments in the industry by plant visits and summer jobs in the industry.
> "7. To inform engineering students where diesel engines are to be used."

The response of technical institutions has been good. As Leonard Arnow of New York University has written: "This type of program might easily be applied to almost any branch of the engineering field and would, if adopted widely, probably result in a higher grade engineering graduate." [12]

Avenues of Improvement

Having discussed sound and helpful aspects of industry-college relations, I turn to certain aspects which fall short of what we should be aiming at and do-

[12] "How Industry Can Aid Higher Education," Leonard Arnow, *Journal of Engineering Education*, Vol. 39, No. 4, December, 1948.

ing. I present these not dogmatically but as questions.

Are we as engineering educators really doing something constructive about the recommendations of the 1944 Committee on the Aims and Scope of Engineering Curricula? The Committee proposed, you will recall, differentiated undergraduate training for three groups of students, including those preparing for jobs in the operation and management of industries.

Are we as engineering educators impressing upon our students going into industry "the humanistic social aims" advocated by the 1944 Committee, goals such as these:

> "Acquaintance with some of the great masterpieces of literature . . . ;
>
> "Development of moral, ethical and social concepts essential to a satisfying personal philosophy and to a career consistent with the public welfare;
>
> "Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study."[13]

Are we of the standard engineering institutions doing our share toward the development of technical institutes which this Association has urged as needed by American industry?

Are we as engineering educators seeking to find and encourage the student possessing genuine research ability? We know that to keep American industry in the forefront new scientific ideas are demanded as a basis for technological advances. As President Conant of Harvard has reminded us, the heart of the problem is to attract "men of brilliance and energy" and to launch such men "on careers as independent scholars with the minimum of elapsed time."[14]

[13] Report, H. P. Hammond, *Journal of Engineering Education*, May, 1944.

[14] Harvard College, President's Report, 1943–44, p. 86.

Are we of the engineering institutions reminding industry that it should help institutions to pay better salaries? The late Thomas Midgley, of the Ethyl Corporation, used to declare that fundamental research problems should be delegated by industry to the "research staffs of our universities and colleges for study."[15] In the years since Midgley said that, educational institutions have been hard put to it to hold able members of research staffs, often because industrial laboratories offer the research educators salaries the educational institutions cannot possibly afford. The same situation exists in regard to teachers of technical subjects. Since first-rate graduates for industry cannot be produced under the tutelage of third-rate teachers and mediocre research staffs, it would be an enlightened policy for industrial corporations to include in their budgets generous annual appropriations for educational institutions. That, in the long run, would be good business.

As to the long run, do we engineering educators lose heart because of occasional economic and financial reverses, because of manifestations of intolerance and greed?

Do we cherish the conviction—and preach it to our students—that the American system of free enterprise *can* be capably operated, that the American faith *can* be truly purified so that our people, possessing economic means and the leisure afforded by science and technology, shall live the life of the spirit—a life fulfilling the dreams of our forefathers and our own highest aspirations?

[15] "The Future of Industrial Research," p. 39.

Education for a Profession[1]

By WILLIAM F. RYAN

Engineering Manager, Stone and Webster Engineering Corp., Boston, Massachusetts

Considerable confusion has arisen in the minds of some educators in regard to an alleged deficiency of engineering training in this country, based on developments during World War II. It has been said that our engineers were not sufficiently grounded in science to handle the problems of modern warfare, and that physicists had to "take over."

This confusion arises from the fact that, for the first time in history, physicists saw radically new concepts translated into practical and effective developments within their own lifetimes. Within a few years after the identification of submicroscopic quantities of fissionable material, they saw the construction of the fabulous plants at Oak Ridge and Hanford and the production of fissionable materials in quantities sufficient to end the greatest of all wars. While many of the top flight physicists engaged on the Manhattan Project were educated abroad, the contribution of American-trained scientists was magnificent. They were able to obtain all of the basic data required for plant design. As a result, a large portion of the American people have been led to believe that the atomic bomb sprung full blown, from our physics laboratories, like Venus from the sea. Actually, however, the extrapolation of these data into billions of dollars worth of plant and equipment was an engineering achievement. It was done by men who knew how to design unprecedented machines, machines that could be readily manufactured in quantity, and which could be operated by unskilled or semiskilled people. It was done by men who knew where and how to get equipment made, how to assemble the men and materials for vast construction projects and how to direct the work. It was accomplished by men who knew enough for the purpose at hand.

In the field of pure physics, we had no demonstrable advantage over the enemy, or over our British allies. The difference lay in our production capacity, itself an engineering achievement, and in our capacity for effective design and speedy construction of unprecedented projects. The great American engineering organizations, and their personnel educated in American engineering schools, account for the fact that the first atomic bomb fell on Hiroshima and not on Philadelphia or New York. Technologically, our engineering schools are doing a magnificent job.

Professional Education

If science and skill were the only attributes of a profession, we should have no grounds for complaint about present day "Education for a Profession" in engineering. There are other attributes, however, and the majority of graduates are lacking in these attributes. This lack can be illustrated by a recent interview with a young man who is a junior in an outstanding engineering school. The young man is an exceptionally attractive candidate for employment in our organization, and we hope he comes to work for us when he is graduated. He is a good student with a scholastic average in the upper eighties and, at the same

[1] Presented before the Middle-Atlantic Section of the A.S.E.E., Philadelphia, Pennsylvania, December 11, 1948.

time, he is prominent in athletics. He has been elected to two honor societies. He is definitely a superior candidate for employment in our kind of business. *But he is professionally illiterate!*

In the course of our interview, it was pointed out that there is no certification of Engineers-in-Training in Massachusetts and it was suggested that he take the examination for such certification either in his home state of New York, or in Pennsylvania where he attends college, as soon as he obtained his degree. He was puzzled and dismayed. He had never heard of such examinations. In fact, he first said he had never heard of registration of professional engineers, although he remembered, later, that it had been mentioned in something he called "Freshman Orientation." The whole business of registration examination was disturbing to him. It was suggested that he should regard the process of registration as a privilege rather than a hardship, but his anxiety was not assuaged.

This rather shocking discovery that a high standing junior in a leading engineering school was not informed regarding the legal status of his future profession prompted further questioning. It developed that this boy had never heard of Canons of Ethics for Engineers. He did not know whether his curriculum was accredited by ECPD; in fact he had never heard of ECPD, although he is a student member of one of the constituent societies, and one of his professors, whom he greatly admires, is active in the work of the Council.

The student told us, not without visible awe, that this particular professor didn't have to teach; he had been offered a job by Westinghouse! "Then, why," he was asked, "do you suppose he teaches?" He could think of a few superficial reasons why an otherwise sensible man might prefer teaching to working in industry, but no question we were able to ask elicited the slightest suggestion that the professor might believe that by teaching he is fulfilling his higher duty to mankind. There was simply nothing in the boy's consciousness that could conceive of such an attitude!

A student in a medical school is indoctrinated with the concept that he is a dedicated person—dedicated to professional ideals, governed by professional ethics and devoted to the service of mankind, from his first freshman assembly to his graduation exercise, when he takes the Hippocratic oath. If engineering is to emerge from its present heterogeneous condition where the actual practitioners are hazily grouped in the public mind with a fringe of master mechanics and variously trained technicians on one side, and physicists, chemists and other pure scientists on the other, professional concepts must also be inculcated in our engineering schools.

What Is a Profession?

The starting point is to make sure that the student knows what a profession is.

The engineers have gone to some pains to define a profession from their own point of view and, in 1945, the Engineers' Council for Professional Development adopted the report of their Committee on Professional Recognition, which expounded the attributes of a profession and its practitioners.

Let us review the attributes of a profession:

1. *"It must satisfy an indispensable and beneficial social need."*

That is obviously an attribute of engineering but it is also an attribute of plumbing.

2. *"Its work must require the exercise of discretion and judgment."*

That would apply to the work of master plumbers and many other noprofessional people. For example, farmers must exercise discretion in regard to when to plant and when to reap and exercise judgment in regard to what to plant and where to plant it.

3. *"It is a type of activity conducted upon a high intellectual plane."*

We are now becoming more exclusive; we have eliminated the plumber and the average farmer and have arrived at groups who have had a higher education and a rigorous training in a specific field. Clergymen and doctors, lawyers and engineers fit into this category because their knowledge and skills "are not the common possessions of the general public; they are the results of tested research and experience and are acquired through a special discipline of education and practice." This knowledge and these skills are, of course, the sine qua non of professional status. No amount of academic culture, social consciousness or idealism can create a profession in the absence of technological excellence. This attribute we have in full measure, and we must guard it and nurture it to the limit of our capacity. We must permit no compromise with knowledge or with skills, but these alone do not create a profession.

4. *"It must have group consciousness."*

This group consciousness is obviously possessed by doctors and lawyers. Reflect on the American Medical Association and the American Bar Association, and compare these practical demonstrations of "group consciousness" with the incoherent organization of engineers! Less than half of the practicing professional engineers in the United States have allied themselves with any of the major engineering societies "for the promotion of technical knowledge" and an insignificant number are engaged in any form of promotion of "professional ideals" or "rendering social services." To the extent that engineering possesses this attribute of group consciousness at all, it is demonstrated almost entirely on the technical side. Promotion of professional ideals and the performance of social services are left to a small and devoted group in each of the senior engineering societies who have sponsored the Engineers' Council for Professional Development and in the relatively insignificant proportion of professional practitioners who are active members of the National Society of Professional Engineers, which is only now approaching a membership of 25,000. If engineers were possessed of the group consciousness that is an essential attribute of a profession, NSPE, the one engineering society which is organized solely for the promotion of professional ideals, would have at least 150,000 members.

5. *"It should have legal status."*

Engineering possesses this attribute, technically, because it has been given a legal status in all of the states of the union and in most of the territories. However, it is improbable that 50% of the men now practicing professional engineering are registered under the laws of these states and territories, whereas 100% of the doctors and 100% of the lawyers are so certified; they cannot practice their professions unless they are. To make a profession of engineering, legal status cannot be left to the statute books alone; it must be accepted in the minds of engineers.

Attributes of Professional Practitioners

Turning to the attributes of professional practitioners:

1. *"They must have a service motive."*

That is a new concept to many mature engineers, as well as students. The 30% or thereabouts who have joined major engineering societies, or at least the 10% who are active in the work of such societies, indicate that they carry their service motive to the extent of "sharing their advances in knowledge." The engineers, however, who are doing anything notable toward "guarding their professional integrity and ideals and tendering gratuitous public service" are regrettably few. Still, this is the first attribute of a professional practitioner and an attribute that must be understood and accepted before one can hope to qualify as a professional man.

2. *"They must recognize their obligations to society and to other practitioners by living up to established and accepted codes of conduct."*

Note particularly their obligations to "other practitioners." If there were a genuine recognition of this obligation on the part of employed engineers and on the part of the engineers who employ them and direct them, most of the problems involved in professional employer-employee relations would evaporate, for this attribute requires that both the employer and the employee must discharge their obligations to one another "by living up to established and accepted codes of conduct." There is no need for collective bargaining in a truly professional atmosphere.

In regard to "living up to established and accepted codes of conduct," the doctors and lawyers have had established codes, rigorously observed, as long as any living practitioner can remember. After 17 years of labor in our loosely organized engineering profession, if one may call it organized, we have at last arrived at a common code of ethics applicable to all professional engineers and all Engineers-in-Training. This is known as the Canons of Ethics for Engineers, ratified by the Engineers' Council for Professional Development in October, 1947, and subsequently endorsed or adopted by nearly every major engineering society of professional grade, including ASEE. The Canons of Ethics for Engineers should be known to every engineering student. They point out a way of life that will be a beacon of professional conduct from his first job to the end of his career. The established Code of Ethics of the American Medical Association and the Canons of Ethics of the American Bar Association are taught to every student of either profession and they are graduated, not only with a knowledge of these codes, but with a profound respect for their tenets. The neophyte in the medical or legal profession accepts his code of ethics "not in passive observance, but as a set of dynamic principles guiding his conduct and way of life." He understands that "the keystone of professional conduct is integrity." He accepts the principle that "it is his duty to interest himself in public welfare, and to be ready to apply his special knowledge for the benefit of mankind."

These words are quoted from the Engineers' own Canons. Do engineering students know them? Do they accept them? Unless they do both, know them and accept them, "not in passive observance, but as a set of dynamic principles," they are not prepared to take their places in professional life.

3. *"They must assume relations of confidence and accept individual responsibility."*

This attribute is one which engineers, for the most part, possess to a high degree. This individual responsibility covers a wide field. It means that an engineer cannot pass the responsibility for the safety and adequacy of his work to anyone except an engineer senior in authority to himself. He cannot pass the responsibility for unethical conduct to anyone at all.

4. *"They should be members of professional groups."*

This attribute, I have said, is practiced by something less than half of our engineers. The further requirement, "they should carry their part of the responsibility of advancing professional knowledge," is an obligation accepted by a smaller proportion, while the part which has been emphasized repeatedly, their obligation to carry their part of the responsibility for advancing "ideals and practice," is a matter of concern to regrettably few.

"A Ministry to the People"

Dr. Vannevar Bush has summed it all up in an address which he made at the hundredth anniversary of the founding

of Lawrence Scientific School at Harvard University:

"The hallmark of a profession, originating how far back in the dim past we cannot surmise, is that its members minister to the people. It is out of this concept of ministry—of the assuming of responsibility for the vital affairs of others because of superior specialized knowledge—that there have grown the idealism of the professional man and the recognition in him by others of a quality of altruism which is its own reward. Upon this recognition by the people is based the continuance of a profession, for it exists only as the people, because of confidence in its integrity and faith in its general beneficence, permit it to maintain its prerogatives and to speak with authority in its own field. A profession is a class apart, but apart because of admitted dedication, not because of special privilege or falsely assumed superiority."

It is such a conception of engineering as a profession, "a ministry to the people," that should be inculcated in our schools.

New Courses Not Essential

Every campus has, or should have, student sections of the major professional societies. However, let us not start, in the cradle, to build up barriers between mechanical engineers and electrical engineers, with further fragmentation of the electrical men into electronics, illumination and communications groups. Let there be one engineering society on every campus to which every engineering student belongs. Let individuals pay their dues to the A.S.M.E., the A.I.E.E., and the others, wear their buttons and read their journals, but when they meet, let them spend their precious time meeting together. Also, let their discussions be concerned with what Dean Holbrook has called the "Engineering Facts of Life," rather than with technical problems now ably presented in the classrooms. The faculty should provide leadership for these discussions, and take an active interest in awakening the professional consciousness of every student who aspires to practice engineering.

It would be unfair to imply that all engineering graduates are professionally illiterate. Many faculties are doing a splendid job of professional development. At Iowa, the student sections are organized exactly as here proposed; Dean Kimball at Dartmouth and Dean Alexander at Northeastern are giving courses in "Professional Relations." At the other end of the scale, however, we have institutions where the professional aspects of engineering are ignored.

Teachers of engineering, giving their lives for the education of youth and the advancement of applied science, certainly fulfill Dr. Bush's concept of "a ministry to the people." Let us infuse this same devoted spirit into the lives of students, so that the engineer of the future may be as notable for his professional idealism as for his technological achievements. Let us send the young engineer out into the world, thoroughly instructed in the "Engineering Facts of Life," and prepared to fulfill his destiny as a member of an engineering "ministry to the people."

Coming in the April issue . . .

Articles of Interest to

YOUNG ENGINEERING TEACHERS

Two-Way Cooperation in Improving Engineering Education*

By AUSTIN WRIGHT

Head, Department of English, Carnegie Institute of Technology

The thesis of this paper is simply that for effective cooperation between English and technical departments there must be sincere devotion on both sides to the common task. Our goal is the *improvement of engineering education;* our primary responsibility is to the student whom we are preparing for professional life; and whatever contributes most significantly to the development of leadership and professional distinction and intelligent citizenship in our graduates deserves our wholehearted support even at the cost of lesser objectives, departmental or personal.

In presenting my ideas I must perforce draw largely upon our experience in what is called the "Social Relations Program" at Carnegie Institute of Technology, and I hope that I shall be forgiven if I sometimes inadvertently leave the impression that we at Carnegie believe that we have discovered all the answers. We are, alas, as keenly aware of our shortcomings as we are of the most hopeful evidence of success. We realize that the potential advancement yet to be made dwarfs what we have thus far accomplished, but at the same time we are convinced that we have made progress.

Before proceeding to details I can summarize my views at the outset by stating that success depends primarily upon (1) cooperation of administrative officers and of department heads and teachers in engineering and science with the program in English and (2) development of a program in English that makes such cooperation desirable and indeed inevitable from the point of view of the teacher of engineering and science by teaching in the English courses fundamental principles and abilities which will be strengthened by use in other courses and in professional life, and will make a substantial contribution to the student's work in other courses and to his attainment in his profession. And here let me anticipate by giving assurance that I do not mean to advocate, for the English training of the engineering student, regimentation in routine forms. Quite the contrary: I mean to recommend the teaching of English composition as a means of clarifying the student's own thinking and strengthening his skill in communication; I mean to speak not in terms of so-called "practical courses" but in terms of developing in the student the power to think and write effectively in the countlessly varied situations (many of them unpredictable) which he will face later.

Necessity of Administrative Support

To proceed, then: Two-way cooperation depends first of all upon the enthusiastic support of the college administration. Members of this Society do not need to be reminded of the crusade which President Robert E. Doherty has for many years led against professional isolation in engineering education. In

* Presented at an English Conference on "Cooperation with Technical Departments," 57th Annual Meeting of A.S.E.E., Troy, New York, June 24, 1949.

particular, emphasis upon the importance of effective training *in English* and the necessity for cooperation in that training by teachers of engineering and science runs with tidal strength through his published utterances and through the memoranda issued for the guidance of our own faculty.

Of countless instances that might be cited, I select two. The first is from an article in the JOURNAL OF ENGINEERING EDUCATION written just before Dr. Doherty assumed the presidency of Carnegie: "The final aspect that I wish to emphasize is the ability to write well. The importance of this in the upper levels is too obvious to be argued. Although this alone might be sufficient to warrant great emphasis upon such ability, there is yet another equally important reason, namely the connection between good writing and good thinking. There is no better discipline in straight thinking than the insistence upon a clear and logical thought structure in written analyses or expositions. These should not be mere description or paraphrases of some published work, but the student's own analysis of a question or problem in the light of his purposeful reading. A written statement is a faithful mirror of the state of one's thoughts; and a discipline which brings about a rearrangement of material and phraseology into a logical and unified form, implies also a corresponding readjustment of thoughts in one's mind." †

The second quotation is from a campus statement of policy dating from 1945: ". . . the problem of teaching good English composition to engineering students involves seeing not only that the courses in English composition focus upon the types of writing which are important in engineering study and work, but also that throughout the science and engineering courses problems are given which involve the arrangement of concrete material and scientific principles into logical and unified *written* statements. The discipline in scientific thinking which this procedure gives is as essential a part of technical training as is the use of physics and mathematics in engineering study. Moreover, unless such problems are given in the scientific and technical courses, the teaching in an English composition course of accurate use of English in scientific thought will be but an empty form."

This administrative policy of unequivocal insistence upon the importance of English in engineering education, reiterated and watchfully supported by the Provost and the Deans, not only lays the basis for two-way cooperation but is the most important single element in its achievement.

Cooperative Endeavor

The second requisite for success is a common meeting ground on which officers responsible for administration of central educational policy, representatives of departments offering the basic courses in mathematics, science, and drawing, and representatives of departments in the humanities and social studies may assemble to study the problem of improving engineering education from all angles and devise means of joint operation which will make clear not only to students but to teachers in widely different fields the essential unity of that education. This common ground is provided at Carnegie in our Basic Course Committee. Implicit in the Carnegie plan of professional education is insistence upon teaching the student to use fundamental principles in dealing with situations that are new to him and upon having him do more of the work in the learning process and having the teacher do less of the thinking for him; the Basic Course Committee has attempted to formulate the method of dealing with a professional problem in any field, and the statement of procedure thus jointly developed is used in common by our teachers of science, engineering, humanities, and social studies. Thus it quickly

† *Journal of Engineering Education*, XXV (1934–35), 37.

becomes clear to the student that the orderly method of solving problems that is characteristic of the trained engineer is the very same method followed by the writer in solving a difficult problem in communication.

The Committee referred to is a clearing-house for the exchange of experience as to the application of this professional method in all basic courses: the Department of English, for example, has the opportunity to learn of instances of effective teaching in technical departments and to suggest means whereby reiteration or extension of techniques taught in English composition should be incorporated in a course in science or engineering, and teachers in technical departments in like manner learn procedures followed in the English course and have an opportunity to suggest alterations designed to prepare the student more effectively for writing problems which he will encounter in technical courses and in his professional career. Not the least important result of such joint study is the realization that all of the teachers concerned are workers in the same vineyard, with a resultant improvement in inter-departmental relations and in turn a similar realization among the students that their work is integrated, not compartmentalized, and that English, in particular, is of vital concern not just to English teachers but to every man preparing for a career in engineering or science.

The effective inculcation of this lesson depends in large part, however, not upon conclusions arrived at in a committee meeting or upon the exhortations of the Department of English, but upon the attitude and example of the teachers in technical courses and particularly upon the backing of heads of engineering and science departments. It was a great humanist who warned, "Our pervasive error is our reliance upon machinery"; and teachers of English know only too well that no matter how imposing, how bright and shiny and mechanically efficient may appear the machinery of cooperation, the wheels will grind to a jarring halt if the operators of the machine neglect it.

In this important respect we in English at Carnegie have reason to be grateful. It is gratifying when an engineering department head takes such an interest in a course in English composition that he devotes many hours to the joint development of communication problems that demonstrate the importance of precise, orderly, crystal-clear presentation of material familiar to the writer but new to the reader; when another engineering department head incorporates as a fundamental requirement of a course in engineering analysis the preparation of a clear account in effective English of the thought process followed by the student in the analysis of each problem; when a third engineering department head leads his students by example and precept into the habit of reading worthwhile literature, and spearheads a drive for the expansion of campus bookstore facilities so that students may be encouraged to buy and read more books; when a professor in Industrial Administration grills his students on word derivations and refuses credit to perfectly adequate solutions of problems in labor management which are presented in slovenly and inept language. This is a far cry from the day when, as a cub instructor who was failing a student for writing not English but Choctaw, I was reproved by an irritated professor of engineering in these words: "Why, that boy writes as well as *I* do." I confess that since the statement was doubtless true, I was at a loss for an answer.

Role of the English Teacher

It is clear, of course, that in spite of the importance of administrative encouragement and the aggressive cooperation of colleagues in technical departments, the teacher of English must himself do a superlative job in the classroom and in conference if he is to play an adequate role in that improvement of engineering

education to which we are all dedicated. The recruitment of a staff of able, stimulating, resourceful men sincerely interested in the teaching of English to students whose major interests lie elsewhere is one of our principal concerns at Carnegie as it is at every technical institution. We believe that we have been fortunate in this respect, but we are aware that the task demands constant vigilance. Teachers of the right stamp are not easy to find; and when found, they are not easy to hold. Moreover, the teacher must be given a work load sufficiently light to permit him to perform the meticulous, time-consuming, exhausting labor of reading and criticizing student writing and holding those frequent individual conferences in which the most effective teaching of composition is carried on, and yet have time for thoughtful planning and discussion with colleagues as well as for at least a modest program of the independent research or creative effort so essential to continued intellectual growth. With a normal teaching load of nine class hours per week for professors and twelve for teachers in other ranks, we have succeeded for the most part in limiting composition assignments to one or two class sections per teacher, rarely three. Effort is made constantly to keep enrollment per section at an effective minimum, and though numbers occasionally creep into the high twenties, the average enrollment in freshman composition in the past semester was twenty-three. And we have been fortunate in recent semesters in being able to reduce the teaching load of one staff member by one-half and two others by one-fourth to allow them time for research and experimentation in teaching techniques.

Improving the Selection

A basic requirement in improving the quality of engineering graduates is improvement in the selection of entering students, and here is an important respect—often neglected—in which cooperation is necessary on the part of officers responsible for admissions to engineering colleges. Put bluntly, the truth is that if we are to get the students best qualified for study leading to a career in engineering, we must not only attract students interested and skilled in mathematics and science but reject those who have been propelled toward engineering simply by distaste for the humanities. The following sentence from the test paper of a candidate is all too characteristic: "I know I want to be a chemical engineer because (1) My interest lies in this field because, in looking over the subjects the various colleges give to engineering students, I found that these are the subjects I want to spend my life in studying and using; (2) There are no subjects which belong to the 'arts' in an engineering course." And occasionally applications are received from students whose writing is so wretched that one is amazed that their high-school advisers encouraged them to regard themselves as candidates for college entrance. Here is the opening paragraph of one test paper: "Chemistry is broadening in scoop every day with new discoveries. Thus new fields of work are constantaly opening upmaking new job to be had. This has cause a greater demand for train chemist in every field of intrustry." Any college which succeeds in making a "train chemist" out of that boy will have accomplished a miracle. What I should like to see is a growing conviction on the part of high-school students that to qualify for admission to a college of engineering and science they must be competent in English as well as in mathematics and science. Whether such a state of mind can be created, I do not know; but we should do all we can to create it not only in the students but in their high-school advisers.

Though this problem is one that still awaits satisfactory solution, the administration at Carnegie has taken two steps in the direction advocated by the Department of English. First, admissions officers are giving more consideration than in the past to the showing made by applicants in high-school English and in

the English section of any entrance or diagnostic tests which they may have taken. Second, students who take the Pre-Engineering Inventory Examinations on the campus are given an additional hour test in English in which they write an impromptu paper which is read and graded by the Department of English: with rare exceptions for the possible genius in mathematics who verges upon illiteracy, applicants who do so badly on this test that they are recommended for rejection by the Department of English are rejected, and applicants whose writing places them in the doubtful category are admitted only if their record in technical subjects is outstanding. We try in this way to alleviate that situation familiar to all teachers of English in engineering colleges: the necessity of expending upon a few very weak students who should not be in college the precious time and energy that should be devoted to helping intelligent young men who are likely to become really competent engineers.

Program of the English Department

Thus far I have touched but little upon the share of the English department in the "two-way cooperation" which is my theme, and therefore it is high time to summarize briefly our formal program of instruction in English. In a basic three-credit course in composition in each semester of the freshman year we try to play our part by teaching a course that contributes in the fullest possible measure to the professional stature of the engineering student. We try both to inculcate the fundamental knowledge and routine skills of English composition which should be, but seldom are, acquired in preparatory school, and also specifically to train the student in that professional approach to the solution of problems in communication which I have discussed earlier.

The development of such a course is by no means easy. After some four years of wrestling with it we are still far from a full solution. We have had to learn from experience what skills in the routine formation of intelligent and effective sentences and paragraphs have to be taught and how best to teach these. Then when we can assume some ability to express ideas effectively, we have to decide what type of ideas and what type of communication are of fundamental significance to a student preparing for a professional career and expecting also to play his part as a citizen. Here we have to guard against the danger to which I alluded near the beginning of this paper: though it is important to make our course contribute as fully as possible to the student's response to all aspects of engineering education, it is equally important to give the student power to think for himself rather than cramping his originality within the confines of routines. Our aim is to teach English composition so as to make it a powerful tool which the student uses throughout his educational training and his professional career, both to clarify his own thinking and to communicate it to others.

Basically the freshman course as we hope to develop it will consist of a series of problems. We are constantly experimenting to devise problems intended to teach a point of grammar or punctuation or sentence structure by induction from examples rather than as a rule copied from a textbook—and only the problems that prove practically useful in the classroom are retained. We are constantly experimenting to devise similarly useful problems intended to demonstrate to the student that the procedure which one has to follow in solving a problem in communication is precisely the same as that which one follows in solving any other sort of problem—in mathematics or science or economics or psychology. And we are constantly experimenting to devise problems that make clear that the intended recipient of a communication is an all-important factor to be kept foremost in the mind of the writer, and that when one has determined exactly what he wishes to write he has performed

only the easier half of the task of communication—he must devise the most effective means of communicating his ideas to his particular reader. Some of our problems have been disappointments, but others have been highly successful; and when we are a little more sure of our ground I should like to have the opportunity to speak before this group again in more detail concerning this phase of our program.

In the senior year most of the departments in science and engineering conduct seminars in which a member of the Department of English collaborates closely with the engineering or science teacher who is in charge. These seminars vary in procedure, but the most widely followed pattern involves student investigation of technical topics resulting in oral and written reports which are criticized by the English representative both in advance and after a speech is delivered or a paper submitted. The senior thus receives, in a course conducted by his own major department, instruction and practice in the supervised preparation of reports and articles and the oral delivery of technical papers on topics of vital interest to him, and the collaboration between English teacher and engineering or science teacher makes for both technical accuracy and effective speech and writing. It is obvious, of course, that these seminars also provide opportunity for both teachers to emphasize the essential identity of the methods of problem-solving in both English and technical courses.

Courses in Literature

In addition to the year of English composition and, in most departments, the senior seminar, all students take in the junior year a semester course entitled "Introduction to Literature." Students who find this course profitable have opportunity to elect one or two additional semester courses in literature in the senior year, making their selection from a wide variety of offerings. Now the question of whether literature—and if any, how much and what—should be taught to students of engineering and science is one concerning which there is endless controversy, and it is far too complicated for discussion here. I shall pause only to subpoena for brief appearances two witnesses from the ranks of the scientists. First, Thomas Henry Huxley, whose famous controversy with Matthew Arnold as to the place of science in education has obscured the broadly humane attitude which that great pioneer of technology expressed more than once in terms such as these: "Literature is the greatest of all sources of refined pleasure, and one of the great uses of a liberal education is to enable us to enjoy that pleasure." My second witness is the great geologist Nathaniel Southgate Shaler, of whom William James said, "Of all the minds I have known, his leaves the largest impression." Shaler was troubled by Charles Darwin's declaration that a lifetime devoted to scientific research had caused him to lose all interest in the poetry and drama that he had enjoyed in his youth. This, said Shaler, is a serious charge—"nothing less than an allegation that natural science tends to diminish the capacity of those engaged in it to enter on those sympathetic relations with their fellows which the higher literature induces." And I am impressed by Shaler's next words: "All imaginable profit from the increase of our knowledge concerning the physical realm would not compensate for such a loss of human power." ‡ In our courses in literature we try to help the student learn how to read worthwhile books intelligently and with enjoyment, and to lead him to develop habits of reading which he will retain throughout life. Though I am aware that we do not succeed with all students, I am convinced that we succeed with many of them.

‡ James and Shaler are quoted by Rollo Walter Brown in "Harvard Yard in the Golden Age" (New York: Current Books, Inc., A. A. Wyn, Publisher, 1948), pp. 111 and 118.

Role of the Student

The student, by the way, is of course a very vital element in any plan of educational cooperation, and we must not lose sight of him. Grimly aware of the truth of the adage about horse and water, we teachers of engineers and scientists know that if we cannot convince the student of the significance and practical value of a subject we lose him. In the teaching of English we often face the special obstacle of student indifference; yet I have long felt that we hold trump cards which we play none too skilfully. If freshmen in engineering and science could be made as fully aware of the importance of English as are graduates of five or three or even one year's standing, English courses would never lack motivation—especially those involving writing and speaking. And the development of such awareness must be our constant concern. "So much of our industrial life involves communication," says one young engineering graduate, "that an engineer unable to express himself readily is as inadequately prepared as one untrained in mechanics or mathematics. . . . His engineering work may be of the highest order, but without the facility for describing its implications he is passed over in the rush and left to wonder why no promotions have come to him." And reiteration of this thought can be found in the remarks of countless young engineers and hard-headed industrial executives. This being so, we are not only missing an opportunity but actually not keeping faith with our students if we fail to acquaint them with and convince them of the facts. In this direction the teacher of English can do something, but because he is subject to the suspicion of special pleading, his exhortations will accomplish little without the articulate corroboration of administrative officers and of technical departments. Of one thing I am certain: the student will not realize the truth soon enough on his own initiative. With regard to English he will say lightheartedly to planners of curricula what Sairey Gamp asked of her employers: "Don't ask me whether I won't take none, or whether I will, but leave the bottle on the chimley-piece, and let me put my lips to it when I am so dispoged."

But that is theme for still another paper! And in bringing *this* one to a close I should like to reiterate what in my opinion are the principal requisites of effective two-way cooperation between English and technical departments: administrative leadership in giving proper emphasis to English as an integral part of engineering education; joint planning which will unite all departments concerned in a common effort and lead in a single direction; wholehearted cooperation on the part of heads of engineering and science departments and their staff members; and equally wholehearted cooperation on the part of the English department head and *his* staff members in the evolution of a program of education in English designed to foster skills and habits which will aid the student both in his subsequent educational training and in his professional development.

College Notes

The Departments of Engineering Mechanics and Aeronautical Engineering, of the **University of Michigan**, offer a Symposium on Fluid Mechanics in the 1950 Summer Session The program will be headed by Professor Sydney Goldstein, FRS, University of Manchester, England, former Chairman of the Aeronautical Research Council of Great Britain and Wright Brothers Lecturer; Professor Leslie Kovasznay of Johns Hopkins University and Dr. A. A. Fejer of the Packard Turbine Laboratories. The program includes talks by these and other visitors, including Professor Arthur Ippen of M.I.T.

What Industry Requires of the Graduate Engineer

A Case Study*

By MARTIN JOHN BERGEN

E. I. du Pont de Nemours & Company, Inc., Newark, Delaware

It is necessary to point out that this case study devotes itself entirely to the performance of a relatively homogenous group of engineering designers. Through the years in which this study took place, the average number of men in this group was approximately 500. Fifty per cent of these men were graduate engineers, and the remainder could be considered as having the equivalent of an engineering degree due to long exposure and experience in design, and design engineering. This group was composed of men in all age brackets from the early 20's to those almost ready for retirement. Therefore, it was considered a group which could be examined on the basis of age and experience as well as performance. It was hoped that the age and experience consideration would give us some measure of the probability of promotion and progress of the younger engineer as he progressed.

It is necessary to point out another fact; namely, that while the methods of measurement, which will be talked about, might be valid for use in other phases of professional engineering work, no claim is made that this is true, because of the lack of data to substantiate such a claim.

Your attention is finally drawn to the fact that while it may seem that this study is quite scientific, we who have been engaged in it for a number of years are fully aware of some of the pitfalls. All of the data are subjective data, obtained by men who arrived at decisions based upon their feelings, experiences, and reactions. These data were subjected to critical statistical analysis, but the fact remains that while we attempt to decrease the margin of error by studying and manipulating the data, we are fully aware of the potential hazards due to our using a number of human beings, each with their individual differences, as measuring mechanisms.

Reasons for the Study

During the War years it became apparent and imperative that those of us who were supervising or managing engineering design have better methods for measuring performance of such engineering work. As a result, a Rating Sheet was devised. It was soon discovered that we were attempting to add apples, oranges and box cars in making a composite rating from the components. Further, we found that any composite rating result had to be scrutinized critically in order to determine what the result meant, if it meant anything at all. These Rating Performance Data were gathered twice a year, over a period of years, by the supervision of the group described a few minutes ago.

After several years of accumulation and study of these data, it was decided to embark on a methodical research program to determine whether or not a "work" function could be derived from the data. The reason for such a study was obvious—it was an attempt to evaluate the professional performance of a large group of workers, whose work covered the entire field of engineering design.

* Presented at a Conference of the Committee on Relations With Industry at the Annual Meeting, A.S.E.E., Troy, N. Y., June 22, 1949.

This field included all phases of Civil, Mechanical, Electrical, and Chemical Engineering. It was felt that, if such a function could be found, then these data would have meaning related to performance. Furthermore, the validity of such a "Work" function might be tested over a further period of time. It was even felt that there was a probability that general job specifications for the professional brackets within the entire hierarchy of design jobs might even be determined.

The Study Itself

As the study itself progressed, various correlations of the component variables of the Performance Rating Sheet ** were made. Two were selected as components of the "Work" function—namely, Quality of Work and Quantity of Work. It was decided that these two component variables multiplied together would give an index of "Work" of a standard of Quality and Quantity, whose maximum would be represented by 100 per cent. Further study on the remaining variables, which were equated to "Work," showed that two component variables had no relation to this defined "Work." Strangely enough, these two variables were "Reliability" and "Health." Because of the lack of correlation these two variables were discarded. The remaining eight variables grouped themselves naturally into two classes—those which were learned primarily by formal schooling, and those which we considered "Psychological or Personality" variables. We called the first two the "Ability and Knowledge" factors.

They were:

1. Knowledge.
2. Analytical Ability.
3. Ability to Learn New Duties.
4. Ability to Write and Speak Clearly.

We called the second group the "Psychological and Personality" factors and they were:

1. Cooperation.
2. Initiative and Creativeness.
3. Judgment and Common Sense.
4. Supervisory Ability or Leadership.

It was soon found that these factors were not independent, but were rather inter-dependent. With further statistical analysis, the "Work" function began to take shape as a power function with powers of the factors all multiplied together. For convenience, the logarithmic form was used in making the correlations and determining the coefficient relationships. Due to the inter-dependence of the variables, certain postulates were used. Undoubtedly, these were of an over-simplifying nature but they enabled us to make a good first approximation.

Since the correlation of ten factors each on 500 items presented no mean task, it was decided to use a sampling technique. Two five per cent samples were drawn at random from the data covering the entire population. We were quite startled with the results on the first sample and immediately went through the check correlations and analysis of variance of the second sample to determine whether or not there was a serious error in either our technique or size of sample. When we found that the check results agreed with the original results well within the limits of error, we found that we had a "Work" equation evaluating "Work" in terms of the two sets of factors; namely, the "Ability" factors and the "Personality" factors.

Using this equation as a criterion, we then subjected our Job Evaluation procedures and weights to analysis, and modified these procedures so that the weights gave good correlation with performance rating weights.

Results of the Study

As I said before, the results of the study startled us when we made the check analysis. By the time we made the check analysis our faces were somewhat red, because we found that we were paying two dollars for the "Psychological and

** The charts described in this article can be obtained from M. J. Bergen, Chief Draftsman, E. I. du Pont de Nemours & Co., Wilmington 98, Delaware.

Personality" factors for every dollar we paid for the "Ability and Knowledge" factors on the more responsible jobs. While we had all known that these psychological factors were important, I think it can be taken for granted that all of us engaged in the study felt that the academic learning carried far more weight than we subsequently found to be true.

As a result, however, of the study, we have had to change our thinking radically. Our attitude toward the academic learning or the "Ability and Knowledge" factors presented no difficulty, because these were the factors that we had all been specifying and measuring.

The greatly increased importance attached to the "Psychological and Personality" factors posed a number of new questions, however. Because of the weight of these factors, it became quite necessary to ask ourselves:

1. How can we teach cooperation, initiative, creativeness, judgment, common sense, supervisory ability, or leadership?
2. What are these psychological factors composed of?
3. How are these personality characteristics learned?

We are still engaged in trying to find the answers to this disconcerting new series of problems.

Objective Check

The modified Performance Rating Sheets and Job Evaluation Sheets were submitted to our supervisors for a thoroughgoing test. These supervisors (25 in number) rated the job components in the Job Evaluation Sheets in the entire hierarchy of jobs under their control, in the same manner that they had been rating the man characteristics in the Personal Rating Sheets. This gave us a picture of the growth or decrease in importance of either set of factors. It was found that, starting with the junior draftsman level—the young man just out of school—and running out to the older experienced man of 50—there was a consistent increase in importance in the "Psychological" variables. We felt, therefore, that we were on the right track.

The composite figures for these Job Evaluation factors are given as follows:

	Psychological Factors	Ability Factors	Total
Junior Draftsman	89.72	127.06	216.78
Draftsman	139.20	166 98	306.18
Designer	199.34	187.89	387.23
Leading Designer	266.15	203.46	469.61

The limits on the values are approximately $\pm 5\%$.

It was quite obvious that, as we went up the job ladder to section leader and beyond, the "Psychological" variables assumed a greater portion of the total weight, even though there was an increase in the "Ability" variable requirements.

Findings and Implications

What are the implications of this study?

In searching to determine what we shall do and how we shall do it—in the training of men in engineering, we have suddenly found that the continuous demand for more varied, newer and more diverse "ologies" constitute a chasing of a "will-o'-the-wisp."

In the past, we have thought that an increase in our demands for more and more diverse technical courses would solve the problems of training men for responsible engineering supervisory positions.

Today, we know that we must train these men in cooperation, initiative and creativeness, judgment and leadership, ability to teach, and supervisory ability.

These psychological factors just enumerated, which are the most important ones for the individual, his family, industry, and the nation, are intimately

associated with attitudes—individual attitudes and group attitudes.

Attitudes are emotional in their nature, and we find the young engineer usually ignorant and untrained in the field of human emotion.

Furthermore, we find that engineering supervision still does not have too clear a concept of the importance of knowledge or method of procedure in the field of feeling and emotion.

We also find that very little information is available on how to train the typical professional engineering employee so that he acquires some knowledge along these lines. It is true that there is a great deal written in this field but much of it that can and should be used is not presented in the form where it is readily usable by the engineer.

Finally, we find that the graduate engineer must change his fundamental attitude towards studies dealing with human beings, and must discard his negative attitude before he can acquire a positive learning attitude toward these factors.

Further Implications

Other important implications of a more general nature to us in the continuance of this study are as follows:

1. There must be a great deal of study done to determine how we in industry should teach these important "Psychological" factors.
2. Only by effective training in these factors can we conserve our professional human resources in engineering.
3. We must help devise "ways and means" which the schools and industry can use to assist in training men in these fields.
4. As a result of such training, there must be an increase in individual opportunity, a decrease in frustration, and a decrease in the blocking of routes of progress, or the training in these attitudes will be nullified.

Summary

To summarize, we rather sheepishly hang our heads in industry, because we have been asking for the engineering graduate to be the special peg for the special hole; the specialized peg being made unique by a wide variety of technical training. We have failed, rather miserably, both with ourselves and others under us, to realize that the important thing that we need is taught over a period of years at home, at school, and in industry and represents a general conditioning or set in a person which is the resultant of a series of attitudes toward various groups, and individuals.

At the present time, it is believed that no formal text book is needed to teach these attitudes. Far more important are the attitudes of the high school and college instructor, the parent, the industrial foreman, and executive as teachers and leaders.

Further study is being planned along these lines.

Rule for Identifying Determinate and Indeterminate Structures

By BORIS W. BOGUSLAVSKY

Professor of Architectural Engineering, Georgia Institute of Technology

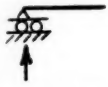
A statically indeterminate structure with respect to reactions is defined as a structure in which the number of unknown reaction components exceeds the number of independent equations of statics. The difference between the two numbers establishes the degree of indeterminateness of the structure.

The problem of determining whether a structure is determinate or indeterminate—and, in the latter case, its degree of indeterminateness—resolves itself into two parts: that of finding the number of reaction components and that of finding the number of available *independent* equations. The first part is simple, the second one occasionally is not. An illustration is offered by a continuous horizontal beam supported at three points and hinged at one of the supports: all engineers recognize the presence of four reaction components, one horizontal and three vertical; some engineers—particularly engineering students—try (and fail) to determine all four by writing three standard equations of statics, $\sum V$, $\sum H$, and $\sum M = 0$, and then supplementing them with a sound but not independent moment equation about a different point in the structure. It can be shown that any moment equation written for the whole structure in excess of the first three static equations can be obtained by combining the three original equations.

The writer wishes to propose a rule which simplifies the problem of determining the number of independent equations of statics available for the solution of any stable structure.

To determine the number of unknown reaction components one must proceed according to Table I.

TABLE I

Support	Number of unknown components	Description of the unknowns
 On rollers	1	Magnitude of the normal reaction
Hinged	2	Magnitudes of two forces, usually horizontal and vertical components of the reaction
Fixed	3	Magnitudes of two forces and of one moment

For instance, in Fig. 1 there are three unknowns, two at the hinge and one at the rollers, in Fig. 2 there are six unknowns, two at each of the three supporting hinges, in Fig. 3 there are seven unknowns, three at the fixed end and two at each of the two hinges, and in Fig. 4 there are eight unknowns, two at each of the four hinges.

The number of independent equations of statics is given by the formula

$$n = 3 + \sum(p - 1)$$

where

n = number of independent equations,
p = number of separate (completely disconnected from each other) parts of the structure which are formed upon the removal of one internal hinge; p must be determined at every internal hinge which, upon its removal, causes a separation of the structure into distinct parts; the hinges must be removed one at a time.

The formula may be analyzed by reference to Figs. 1, 2, 3, and 4 and Table II.

Fig. 1

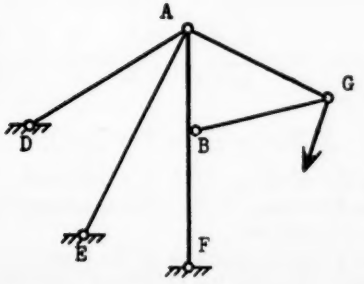


Fig. 2

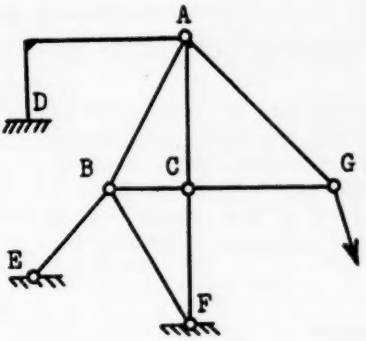


Fig. 3

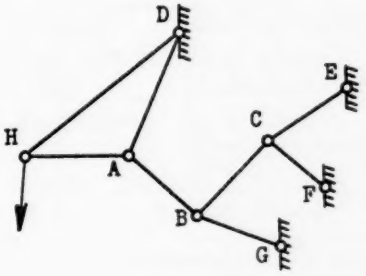


Fig. 4

Hinge B in Fig. 2 and hinge C in Fig. 3 are not included in the tabulation as their removal does not result in the breaking up of the structure into separate parts.

Proof

Notation: In the following analysis subscripts A, B denote points about which moments are taken, and superscripts 1, 2, 3 denote portions of the structure included in the summation of moments. Absence of a superscript indicates that the summation applies to the whole structure.

For the entire structure shown in Fig. 5 one may write three equations of statics:

$$\sum V = 0 \qquad (1)$$

$$\sum H = 0 \qquad (2)$$

$$\sum M_A = 0 \qquad (3)$$

TABLE II

			Figure			
			1	2	3	4
Remove hinge	A	Parts	No internal hinges	AD AE AGBF	AD EBAGCF	ADH ABGCEF
		$p-1$		2	1	1
	B	Parts		—	BE BFCGAD	BADH BG BCEF
		$p-1$		—	1	2
	C	Parts		—	—	CBGADH CE CF
		$p-1$		—	—	2
$\Sigma(p-1)$			—	2	2	5
$n = 3 + \Sigma(p-1)$			3	5	5	8
Number of unknown reactions, r			3	6	7	8
Degree of indeterminateness, $r - n$			0	1	2	0

(or, instead of $\sum M_A$ in eq. (3), one may use $\sum M_B$ or $\sum M_C$, since the location of the point of moments has no effect on the magnitudes of the forces; these alternate equations are not independent, as they can be obtained by combining eqs. (1), (2), and (3)).

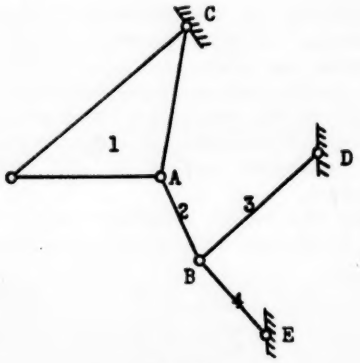


FIG. 5

If the hinge at A is removed, and the structure is divided into two parts, 1 and 2–3–4, only one equation of equilibrium can be written for each part without introducing the unknown internal forces exposed at A, namely, equation of moments about A:

$$\sum M_{A^1} = 0 \qquad (4)$$

$$\sum M_{A^{234}} = 0 \qquad (5)$$

But

$$\sum M_{A^1} + \sum M_{A^{234}} = \sum M_A$$

and therefore eq. (5) is not independent, since it is equal to the difference between eqs. (3) and (4).

In a similar manner, if the hinge at B is removed, and the structure is divided into three parts, 1–2, 3, and 4, one may

write three moment equations without introducing new unknowns, namely,

$$\sum M_{B^{12}} = 0 \quad (6)$$

$$\sum M_{B^{3}} = 0 \quad (7)$$

$$\sum M_{B^{4}} = 0 \quad (8)$$

But

$$\sum M_{B^{12}} + \sum M_{B^{3}} + \sum M_{B^{4}} = \sum M_{B}$$

and, again, eq. (8) is not independent since it is equal to the difference between $\sum M_B$ (which is a combination of eqs. (1), (2), and (3)) and the sum of eqs. (6) and (7).

Thus it follows that when the removal of an internal hinge divides the structure into p separate parts, one may write $(p - 1)$ additional independent equations at that hinge, and a total of $\sum(p - 1)$ additional equations for the whole structure.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	University of Maryland	May 6, 1950	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4, and 5, 1949	C. J. Posey, University of Iowa
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Fall, 1950	F. H. Thomas, University of Buffalo

What's New in Industrial Engineering Curricula?[1]

By EVERETT LAITALA

Associate Professor of Mechanical Engineering, University of Illinois

This is a many sided question, an answer to which would require far more extensive research and study than that upon which this paper is based. The criteria for establishing what is new would call for a study of what is considered old. The questionnaire which I prepared was broad in its implications leaving the respondent to decide what he considered new without explaining what he considered old. The questions were designed, therefore, to throw some light on general trends in the manner in which various schools were providing industrial engineering instruction and something relative to changes in the content of the curricula themselves. The following questions appeared in the questionnaire:

I. In which of the following ways are your course offerings available to the student?

—— Option in Mechanical Engineering.
—— Under General Engineering.
—— Degree granting Department in Industrial Engineering.
—— Degree granting Department in Administrative Engineering.
—— Degree granting Department in Management Engineering.
—— Other? ————————————————

II. When did your present general pattern or method of offering courses in Industrial Engineering take effect?

—— (Approx. Year) Remarks: ————————————————

III. Have you had any recent modifications or additions?

1. In curriculum pattern?
2. New course offerings?
3. New approach to treatment of an old course?
4. Graduate level instruction and research?

IV. Any other comments relative to the question: "What's New in Industrial Engineering Curricula?"

Analysis of Replies

I did not overlook the desirability of making a more objective and comprehensive study, but I felt that at this time at least we were all burdened with "peak load" operations and that such a questionnaire would place an undue load on everyone. Sixty-one engineering schools were contacted and responses were received from forty-six. The schools contacted are listed on an attached sheet.

The following is a summary of replies to Question 1: "In which of the following ways are your course offerings available to the student?

[1] Paper presented before the Industrial Engineering Division at the Annual Meeting of the A.S.E.E., Troy, N. Y., June 22, 1949.

No. of Schools	Manner in which Courses are Made Available to Student
12	Option in Mechanical Engineering.
3	Option in General Engineering.
13	Degree granting department in Industrial Engineering.
3	Degree granting department in Management Engineering.
1	Degree granting department in Administrative Engineering.
1	Degree granting department in Industrial Administration.
4	Degree granted in Engineering and Business Administration but no department designated as such.
2	Degree B.S.I.E. but no such department. Curriculum administered by committee, in one case, and by the M.E. Dept. in the other.
1	Degree Industrial-Mechanical, administered by Mechanical Engineering Department.
3	By a service department called Administrative Engineering or similar title.
2	No so-called option in M.E. but one or two courses in area of Industrial Engineering required. Other courses available at School of Business or Commerce.
1	Degree in Engineering undesignated but I.E. work departmentalized.

The above tabulation does not seem to need any explanation except perhaps to call attention to the fact that the optional approach to providing Industrial Engineering instruction seems to have served its purpose and that the degree granting department is taking over. The above figures are of added interest when related to the second question in the questionnaire.

The responses to Question II: "When did your present general pattern or method of offering courses in Industrial Engineering take effect?" are summarized in the chart on the next page.

These curves seem to have real significance in indicating the growth and recognition of industrial engineering and management instruction in our engineering schools. You will note two curves. One summarizes the trends in Mechanical Engineering curricula as related to Industrial Engineering, and the other, the growth of degree granting departments. Since this study included schools from all over the United States it can be seen that the industrial engineering and management area of instruction in our schools of engineering is no longer considered like frosting on a cake but rather an integral part of the cake itself.

The data seemed to give strong evidence of a rather rapid future growth of degree granting departments. A few letters indicated that the ground work for such new departments was already pretty well laid. While the growth and interest relative to industrial engineering instruction have been steady since the turn of the century, the impact of the late war hastened consideration of the place of industrial engineering in the over-all engineering program. Perhaps the best evidence of this is the curve related to the option in Mechanical Engineering. The curve shows a very abrupt upswing from 1940 on to the present time. This curve should not be taken at its face value to indicate that prior to 1940 a few mechanical engineering departments were offering work in Industrial Engineering. Most schools have made it possible for a student to take some work as electives at least for some period of time. Then, too, it must be observed that this curve applies only to schools still having an option in Mechanical Engineering. It does not include those schools that once had an option but now have a degree granting department. The replies to the questionnaire as summarized by the curve do reflect, however, the fact that since 1940 basic changes have taken place in curriculum patterns in Mechanical Engi-

neering permitting further growth of the Industrial Engineering area of instruction.

Trends in Curricular Programs

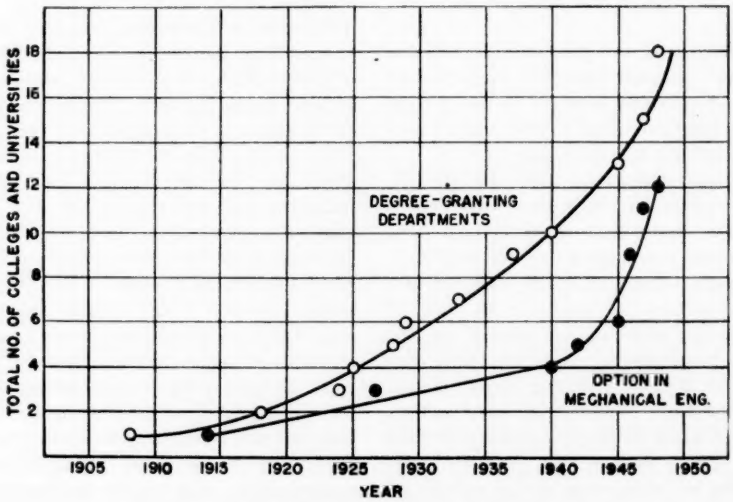
The answers to Question III: "Have you had any recent modifications or additions?" were solicited by use of four subheadings. The responses to each are taken up separately below.

1. *In Curriculum Pattern?*

This subheading to the question was designed to reflect recent changes at those schools that have had either optional programs or degree granting departments for some time. It can be seen that a school which had only recently set up its program as indicated by its response to Question 2 would not be likely to have any change to report. The most common comment was that the engineering curricula in general had undergone study and revision looking toward strengthening and broadening of instruction. In a few schools engineering curricula now call for 4½ to 5 years of study. One of the responses to this question was of real interest. A foundry option was added to the Industrial Engineering curricula in 1948. We have become accustomed to thinking of Industrial Engineering itself as an option but now we have an indication of the development of possible future trends in this area of instruction itself. At one school a new curriculum in Industrial Administration was introduced last year which developed out of their former Management Engineering curriculum. At another school a management engineering curriculum was developed to replace two previous degree granting curricula, namely, Business Administration and Industrial Engineering.

2. *New Course Offerings?*

In answering this question the respondent had to decide what he considered new and what he considered old. The following summary indicates that the one area considered by most as being in the



Growth of industrial engineering instruction *

* Late replies from two Engineering Schools, each having degree granting departments in Industrial Engineering, were not included in chart or other summaries.

bracket of the "new" is statistics and its applications to quality control and other industrial problems. The number following each item indicates the number of schools indicating the course as new to their curricula.

Statistics and their application (10), seminar (3), industrial leadership (2); the remainder were reported by one each: materials handling; nomography; summer work; general course in tool engineering; advanced course in foundry; metallography; manufacturing costs; purchasing; engineering economics; plastic working of metals; production control and motion and time study for non-commerce students; motion and time study for home economics; course in equipment as related to skills for labor economics students; course in motion and time study for chemical engineers, welding engineers and mining engineers; principles of industrial engineering for mechanical engineers; advanced management case studies; fundamental principles of chemical engineering; job evaluation; wage administration; production control; advanced methods study; plant design; course called production engineering for integration purposes; applications of industrial engineering to processing as well as mechanical industries.

3. *New Approach to Treatment of an Old Course?*

It is quite obvious that to answer this question one might have to write at length to get over his ideas. Here, again, the interest was to get a spontaneous comment rather than get a "checklist" type of reply. The following quotations reflect the thinking that seemed representative of most of those who responded to this question: "Increased use of visual aids, particularly industrial movies"; "production design—emphasis on economics of tooling rather than tool design"; "motion and time study merged (two courses before), tool design sequence merged (two courses before), shifted engineering economics from sophomore to senior year"; "less emphasis on motion and time study and more on the broader aspects of the profession"; "all courses are being reviewed to get away from technical details and toward basic principles"; "continuing greater stress on objectivity of approach, use of statistical mechanisms and concept of control"; "cost control, a combined version of general and cost accounting"; "considering emphasis on the case method," and "original problems in motion-time analysis." If one were to give a summary response to this question, it would seem to be that the age of the "glamor" and "technique" kind of course has been passed and that we are in the age of reducing our instruction to a real consideration of fundamentals.

4. *Graduate Level Instruction and Research?*

This question should have been made more objective by use of subheadings. On the basis of the replies it is not possible to provide an accurate statistical summary on such questions as highest degree awarded, number of students working for M.S. and Ph.D. degrees, etc. Of the schools having degree granting departments four indicated work to the Doctorate level, seven indicated work to the M.S. degree, and seven either indicated their graduate programs were not in operation yet or they gave no response. The comments did indicate quite definitely that a rapid increase in number of students entering graduate work in Industrial Engineering is being experienced. Although not so stated there seemed to be an implication too that graduate level instruction would need the greatest immediate attention.

Other Comments

The comments under this question were varied in nature and content, and there-

fore it is difficult again to give any kind of a graphic summary. These comments were of extreme interest in that they reflected, either directly or indirectly between the lines, the serious thought being given to the subject of Industrial Engineering.

The essence of the definitions and other materials sent me was to consider Industrial Engineering in the broad fundamental sense and was not as training for a specific departmental activity in industry.

Under this heading: "What's New in Industrial Curricula?" attention should be directed to the growth of so-called "Industrial Engineering Colleges" offering curricula measured in terms of months or up to two years of instruction. In the sense that these schools may be used as examples of our own professional status, it is well to be familiar with their programs. We should be prepared to place these schools of "Industrial Engineering" into the category of their brethren, namely, schools of "Diesel Engineering," "Radio," "Television," "Electronics," "Aeronautics," etc.

Some Conclusions

1. The growth in numbers of degree granting departments in Industrial Engineering has been a steady, gradual one reaching a point at present which seems to indicate a period of accelerated growth.

2. Most schools seem to use the term Industrial Engineering to designate the department in which such instruction is offered.

3. Industrial Engineering has come of age. Like older areas of engineering instruction, the future will be one of improvement and standardization.

4. Perhaps the only area of work in Industrial Engineering considered somewhat new is the area of statistical methods applied to industrial problems.

5. Graduate students in Industrial Engineering are growing in numbers calling for much immediate attention to graduate level programs and instruction.

6. Attention is called to the growth of trade-type schools of "Industrial Engineering" offering sub-professional work in very limited areas of Industrial Engineering.

SCHOOLS INCLUDED IN STUDY ON
WHAT'S NEW IN INDUSTRIAL ENGINEERING CURRICULA?

University of Alabama
University of Arizona
University of Arkansas
University of Buffalo
University of Calif. (Berkeley)
Carnegie Institute of Technology
Case Institute of Technology
University of Colorado
Columbia University
University of Connecticut
Cornell University
University of Delaware
University of Detroit
University of Florida
Georgia School of Technology
Illinois Institute of Technology
University of Illinois
Iowa State College
State University of Iowa
University of Kansas
Lehigh University
Louisiana State University
University of Maine
University of Maryland
Massachusetts Inst. of Technology
Michigan State College
University of Michigan
University of Minnesota
University of Missouri
Montana State College
University of Nebraska
Newark College of Engineering
University of New Hampshire
New York University
North Carolina State College
Northeastern University
Northwestern University
University of Notre Dame
Ohio State University
State University of Oklahoma
Oklahoma A. and M. College
The Pennsylvania State College

University of Pennsylvania
University of Pittsburgh
Pratt Institute
Purdue University
Rensselaer Polytechnic Institute
Rutgers University
University of Southern California
University of South Carolina
Stanford University
Stevens Institute of Technology
University of Tennessee
A. & M. College of Texas
University of Texas
Thayer School of Engr. at Dartmouth College
University of Vermont
Virginia Polytechnic Institute
University of Washington
University of Wisconsin
Yale University

Important Announcements

The **Humanistic-Social Division** of the A.S.E.E. is planning to conduct a summer school of three or four days duration during the week immediately following the Annual Convention of the A.S.E.E. Sessions will be held at the University of Washington. The general theme will be "The Integration of Humanistic-Social Curricula with the Teaching of Engineering and Science."

This subject, so broad and yet fundamentally important, should interest all members of the Society. Formal papers, panel discussions, and general open discussion will be the methods of handling the problem. Out of the summer school should come ideas valuable to everyone who attends. All members of the Humanistic-Social and English Divisions are urged to stay on after the regular Convention, if possible, to participate in this project. A cordial invitation is extended to members of the other Divisions of the Society to attend the summer school if they wish.

Further information will be published in the JOURNAL as soon as it is available. If you plan to attend, please write Professor Stuart Chapman, University of Washington, Seattle, Washington.

Iowa State College, in cooperation with the **Mechanics Division** of A.S.E.E., is sponsoring a summer school for teachers of Engineering Mechanics. The theme of the school is "Dynamic Teaching of Engineering Mechanics." The program will be organized to assist both the young instructor and the more mature teacher in presenting his subject matter effectively and efficiently. Techniques of presentation and critical analyses of course content will be emphasized. The discussions will be led by experienced teachers, and ample opportunity for participation will be afforded everyone attending.

The school will be held at Iowa State College from Monday, September 11, 1950, through Friday, September 15, 1950. Correspondence concerning the summer school should be addressed to Dr. Glenn Murphy, 101 T. & A. M. Laboratory, Iowa State College, Ames, Iowa.

A Conference of particular interest to young engineering teachers is being planned by the **Committee for Young Engineering Teachers** at the Annual Meeting at the University of Washington. Details will be included in the April issue of the JOURNAL. Younger faculty members in the Pacific Northwest Section and adjoining sections are urged to participate in this Conference. For details write to Professor F. L. Schwartz, Mechanical Engineering, University of Michigan, Ann Arbor, Michigan.

Don't forget the **Teaching Aids Exhibit** at the Annual Meeting. The Teaching Aids Committee urgently requests that if you have developed a useful teaching aid, please write to Professor Carl W.

Muhlenbruch, Northwestern University, Evanston, Illinois, for details as to how you can include it in the exhibit. Here is an opportunity to make your contribution to the objectives of the Society.

An excellent Manual **"Effective Teaching"** has just been completed and is now available. The Manual was prepared by Professor Fred C. Morris of Virginia Polytechnic Institute under the sponsorship of the Committee on Teaching Manual of the Society, and is published by the McGraw-Hill Book Company. The Manual presents in clear, concise form the fundamental principles of good teaching. There are chapters dealing with the planning and organizing of instruction, the use of instructional aids, methods of conducting class sessions, student learning activities, educational measurements, the administration of instruction, and methods of evaluating teaching effectiveness. This Manual is an indispensable asset to the young teachers who wish to gain a new perspective on effective teaching methods. It is available from McGraw-Hill Book Company, 330 West 42 Street, New York 18, N. Y., at a price of 60¢ per copy.

A booklet containing papers presented on the subject **"Cooperative Education at the Graduate Level"** at the Annual Meeting of the A.S.E.E., Troy, N. Y., June, 1949, is now available. The program was sponsored jointly by the Divisions of Graduate Studies and Cooperative Engineering Education. The subject of cooperation between industry and engineering colleges in graduate research is of growing importance to engineering college administrators and teachers of graduate subjects. Papers published in this booklet have been prepared by faculty members, engineering college administrators, and industrialists, who have had first hand experience with graduate programs in cooperation with industry. The material was prepared for publication by the Polytechnic Institute of Brooklyn. Copies can be obtained by writing to A. B. Bronwell, Secretary, A.S.E.E., Northwestern University, Evanston, Illinois. The price is 30¢ each.

A Manual **"Speaking Can Be Easy—For Engineers,"** prepared by the Committee on Relations With Industry of the A.S.E.E., will be available about April 15. The Manual was prepared by a Committee consisting of E. C. Koerper, J. L. Singleton, L. J. Fletcher, S. D. Kirkpatrick, Westbrook Steele, and Ward Delaney. Copies can be obtained from the ECPD, 29 W. 39th Street, New York, N. Y., at 50¢ per copy.

Publication of the Proceedings of the 1949 Annual Meeting of the **Engineering College Research Council**, has been announced by Dean F. M. Dawson, Chairman of the Council. The volume, which presents all papers given before the Research Council at the 1949 meeting at Rensselaer Poytechnic Institute, is highlighted by twelve contributions to a symposium on Instrumentation for Engineering Research. Other papers describe federal military and non-military engineering research interests as reported by research executives in the Army, Navy, Air Force, Public Health Service, Highway Research Board, N.A.C.A., and Department of Agriculture. Copies of the illustrated, 140-page paper-bound book of Proceedings may be obtained from the Engineering College Research Council, at the State University of Iowa, Iowa City, Iowa, at $1.50 to A.S.E.E. members, $2.00 to all others.

Needs of Highway Engineering Education*

By BEN H. PETTY

Professor of Highway Engineering, Purdue University

One could wind up this discussion on "Needs of Highway Engineering Education" in short order, by saying simply that the needs of highway engineering education are "good teachers, receptive students, and adequate facilities." But it is not as simple as that.

Role of Highways in Our Economy

Let's start at the beginning. Should highway engineering be taught in engineering colleges and universities? I say emphatically, yes! We are living in a highway transport economy. Even though this was so vividly demonstrated during the late World War II, far too many of us have already forgotten the lesson it taught us, and, incidentally, many apparently have forgotten the war itself.

We have, in these United States, some 3,000,000 miles of roads and about 300,000 miles of streets over which close to 40,000,000 motor vehicles are operating. These highways are the arteries of travel for the very life-blood of our nation. To be sure, the railroads are doing a grand job of transportation. But where would they be without the highways to feed them a major share of the products they transport? And what about the vast areas of our country not served directly by railroads?

It is impressive to stop and consider the fact that practically everything we wear, the food we eat, the furnishings in our homes, and our houses, business buildings, and industrial plants themselves—all, at some time, either as raw materials or in the form of finished products, were transported over our highways. It would be a waste of time to dwell longer on the vital role played by our highways in promoting and preserving agriculture, industry, education, travel, recreation, and life itself in this broad land of ours.

Why Teach Highway Engineering?

The location, design, construction, maintenance, and operation of our highways now represent an annual expenditure of over two billion dollars. To insure efficiency and economy in this tremendous expenditure of public funds requires an abundant annual supply of well-trained engineers. State, county, and city highway departments are begging for new engineering personnel to build their staffs up to par and to facilitate replacements for the large number of retirements each year.

In view of our absolute dependence on highways for our very existence and our awareness of the acute need for thousands of additional highway engineers, should there be any question as to the justification of teaching highway engineering in our engineering schools? I think not. But it is questioned by many people both within and without the educational field.

Some of our colleagues in the profession of engineering teaching argue that, since our civil engineering students are required to take courses in surveying, materials testing, soils, structural design,

* A paper presented at the Annual Meeting of American Society of Civil Engineers, New York City, January 19, 1949.

hydraulics, geology, mechanics, etc., there is no need of setting up a separate course in highway engineering. May I answer that argument by citing the fact that the highway engineering industry is already seriously handicapped by having far too many engineers on the payroll who are simply locating engineers *only,* structural design engineers *only,* testing and research engineers *only,* and construction or maintenance or traffic engineers *only!* Highway engineers, who have a reasonable knowledge of and interest in the entire field of highways, are few and far between. State highway officials in Virginia, and possibly a few other states, have set up excellent training programs for young engineers wherein they receive training in the various subdivisions to insure a coordinated and comprehensive viewpoint.

One of the main objectives of a highway engineering course should be to impress upon the minds of the students the magnitude and importance of the highway industry, and to emphasize the interrelationships and interdependence of its various subdivisions.

It is a mystery to me why so many engineering schools ignore the subject of highway engineering completely. Yet they will devote equivalent time to other subjects which play a relatively minor part in our economy and offer only a small fraction of the opportunities for employment that are wide open in the field of highway engineering.

I have devoted considerable time to attempts at rationalizing this lackadaisical attitude toward highway engineering on the part of the general public and the teaching profession. My conclusion is that it centers in the fact that far too many of them not directly connected with the highway industry are confident in their own minds that they are curbstone experts on the subject. The highways are right there under their noses; they travel them every day; so why shouldn't they know all the answers?

Good Teaching

Now that we have settled (?) the question as to whether or not highway engineering should be taught in engineering schools, let's talk about who should teach it. Recently, while attending the summer meeting of A.S.C.E., I was approached by a personable young chap who questioned me persistently about how I taught highway engineering at Purdue. He wanted to know about textbooks, assignments, problems, etc. Finally it came out! He was a teacher of structural engineering at a large university who had been assigned by the head of his school to teach highway engineering the following semester. With a teacher who had had no previous practical or teaching experience in highway engineering, what do you suppose his students got out of the course that semester? Some of our students certainly are bears for punishment during these days of doubled and trebled enrollment; and, incidentally, so are the teachers and administrators.

Highway engineering cannot be taught satisfactorily from a textbook *alone.* There are a few good highway engineering books on the market but none is completely adequated for the simple reason that the field is too broad for any one mind to comprehend it fully and set it down clearly in the space available. And that goes for textbooks in a lot of other fields, too.

Textbook knowledge should be liberally supplemented by practical experience, attentive attendance at highway conferences, and *selected* and careful reading of the various printed proceedings, bulletins, magazines, etc., dealing with highway engineering matters. The teacher's spare time is limited these days, and he must develop a keen sense of selectivity to avoid wasting time on non-essential printed matter.

I do my highway extension work primarily during the summer. The work consists, in general, of one-day visits to various counties of the state, on invita-

tion of the local road officials. A tour over a representative group of county roads, in the company of county commissioners and road supervisors, offers ample opportunities for me to learn of the many problems facing these officials, and they usually are in a receptive mood to receive any suggestions or criticisms of their operations I may wish to offer. Similar visits are made to the various state highway district offices, and, in company with the district engineer and one or two of his top men, we ride their district roads for observation and discussion. Occasionally I make a more extensive tour of the state highway system with the state maintenance superintendent. The contacts are helpful, the knowledge gained is valuable, and occasionally some suggestions for improvement can be planted. Similar contacts are made with city engineers, mayors, and boards of public works, to discuss street problems.

Incidentally, this offers excellent opportunities for missionary work in the form of highway education for the public. In most counties arrangements are made locally for me to speak before some group such as Rotary, Kiwanis, or Chamber of Commerce. What such groups *don't know* about actual highway conditions and operations is amazing. The newspapers are very cooperative in giving ample publicity to factual information presented.

Another very valuable adjunct to highway education in my state is the Annual Purdue Road School. Started in 1915 by Professor W. K. Hatt, then Head of the Civil Engineering School, it has been held each succeeding year. It lasts four days and attracts from 600 to 1200 state, county, and city officials, engineers, contractors, materials-and-equipment men, and others interested in highway improvement. Emphasis is placed on the fact that this is a school and not a convention. It provides continuing education for the older men (and by "older" I mean "older in tenure") and, with the frequent turnover in personnel, it helps to get the new men off to a much better start.

Receptive Students

Most students are not born that way. Their interests must be developed, and it is up to the teachers to provide most of the stimulation. Ample background data are available to the teacher for dramatizing the field of highway engineering. The extensive mileage of highways in this country, the vital role they play in our daily lives, some of the awe-inspiring bridges and grade-separation structures, the limited-access highways, the spectacular location and construction in mountainous areas, the billions of vehicular miles of traffic handled, and the amazing variety and sizes of construction and maintenance equipment—all lend themselves to an attractive build-up for interest in highway engineering.

Inspection trips to nearby construction jobs are of educational value and tend to stimulate student interest in highway work.

Teachers of highway engineering should impress upon their students the fact that highway engineering is a continuously functioning field of opportunity which apparently will never be dead-ended by any conceivable changes in future progress in transportation. It is a field wherein periods of depression have little or no effect in reducing employment opportunities. In fact, highway work is more likely to be stepped up during periods of depression as a governmental effort at relieving general unemployment.

Highway engineering provides ample and varied opportunities for the expression of engineering aptitudes in such areas as location, design, construction, maintenance, traffic control, planning, testing, research, etc.

We should be honest in pointing out to our students that there are individual dead-ends in highway engineering, just as there are in other fields of endeavor. But it should be emphasized that these usually come to those individuals whose

progress is slowed to a halt by their own personal shortcomings of personality, character, industry, ambition, resourcefulness, and technical ability.

Teaching Facilities

Good teaching is encouraged and abetted by adequate facilities. I am taking the liberty of calling time a facility. Too many in the highway field expect too much of our students who enter their employ immediately after graduation. Some seem to feel that these boys should have a fairly complete mastery of all the varied and detailed operations involved in highway improvement when they arrive on the job. Before he becomes too critical of the graduate's knowledge of detailed operations, it would be helpful if each critic would stop and ask himself, "Just how much did *I* know about the details of highway improvement when I first came on the job?"

This is not offered as an alibi for the teachers of highway engineering but is merely an opener for a discussion of the total time devoted to required courses in this subject.

At Purdue, all civil engineering students (except in the sanitary engineering option) are required to take two courses in highway engineering, each of two-credit-hour weight. The first covers such items as historical development, highway systems, location, design, earthwork, drainage, all unstabilized road surface types, contract procedures, etc. There is one lecture-recitation a week plus a three-hour drafting period in which, starting with a mile of transit, level, and cross-section notes, students must complete a set of road plans in one semester.

The second course covers such items as bituminous materials and all types of bituminous surfaces, concrete pavements, brick and stone block pavements, soil-cement and cement-bound macadam, highway organization, finance, maintenance, etc. These are covered in one semester in a one-hour lecture and one-hour recitation-lecture per week.

It looks imposing, doesn't it? But if we add up the actual hours in lecture, recitation, and drafting, plus examination periods, it totals just 96 hours. On the basis of an eight-hour day, that would be equivalent to 12 days, say two weeks, in which we are supposed to teach these boys all the things some of you seem to think they should know about highways the minute they step on the job.

Obviously, that is a ridiculous expectation. My objective is to teach these boys (and a few girls) the fundamental principles covering the items previously listed and let them pick up the multifarious details when they get on the job. These details vary tremendously, anyway, as can be ascertained by a perusal of specifications and manuals from different states. So give the boys a break! You will find that, as a usual thing, they will go faster and further than if they had not had such training.

Other facilities of considerable value to the teaching of highway engineering include:

1. Visual aids, such as films and slides, provided by various highway associations and materials-and-equipment interests.
2. Charts, statistical tables, pictures, publications, etc., available from Public Roads Administration, American Association of State Highway Officials, Highway Research Board, American Road Builders Association, and other sources.
3. Samples of materials from various producers.
4. State highway road plans, specifications, manuals, contract proposals, bid tabulations, unit prices, etc., which should be supplied without question to highway engineering teachers.
5. Speakers occasionally from state, county, or city engineering forces from contractors' groups, and representatives of materials-and-equipment interests. The boys get tired listening to us all the time.

6. Summer employment on highway work provided by governmental units and contractors. If this were used on a greatly increased scale, it would react in a very beneficial manner to the industry.

7. Placing of all highway engineering teachers on the complimentary mailing lists of all highway associations, magazines, and manufacturers and producers of road equipment and materials. Better-informed teachers mean better-informed students, and I know of no better future prospective purchasers than highway engineering students.

Graduate Work

We should encourage some of our better students to take a year or two of graduate work, majoring in highways, for a Master's degree. The Joint Highway Research Project at Purdue (financed by the State Highway Commission of Indiana since 1936) has not only uncovered much valuable new knowledge in the field of highways, but also has provided an ideal set-up for graduate work. Under the direction of R. B. Wiley, Head of the Civil Engineering School, and with Professor K. B. Woods in active charge, several Master's degrees have been granted to men who since have made excellent records in state highway work, in research activities, and in the teaching profession. Graduate work of exceptional quality is being carried on in highways at many engineering schools whose graduates have contributed materially to the betterment of the highway industry as a whole.

Mention should be made of the excellent programs under way at the University of Florida and a few other institutions whereby selected highway employees are sent to the university with pay for periods of two or three months for advanced training.

In Conclusion

There is a chronic controversy in educational circles over general versus specialized training, or the humanities versus the scientific. It is a little too deep for me but I can't refrain from a few comments. Certainly a knowledge of the humanities is desirable, but it is our duty as teachers to train students to make a good living as well as a good life. In this day and age we make a living—or else!

Any teacher worth his salt is teaching humanities every day in his classes right along with practicalities, and a lot of such so-called culture is taught without ever opening the mouth. It is lived before the students. So let's don't let such controversies stop the teaching of highway engineering.

I assume full responsibility for the ideas expressed in this paper. They may or may not represent the thinking of my superiors at Purdue.

A Survey of Interest in Electronics Instruction in Engineering Departments

By KARL R. SPANGENBERG

Professor of Electrical Engineering, Stanford University

In the summer of 1948 there was conducted a survey to determine the interest of Engineering Departments other than Electrical in giving instruction in Electronics to their students. The results of this survey are summarized here.

Some 800 copies of a questionnaire on this subject were sent out to Engineering Schools. The group of schools contacted included the approximately 150 engineering schools having a total undergraduate engineering enrollment greater than 1000 students. A 40% return was received on the questionnaires though only about half of the questionnaires were scored in a form that made them useful for tabulation.

The questionnaire contained the following questions: nine questions calling for a yes-no or numerical indication, one question giving a list of topics on which interest could be checked, six questions calling for comments. The questions calling for comments were, in general, so incompletely answered that no tabulation could be made. A tabulation of the results of the other questions is given.

TABLE I

Question No.	Type Answer	Aeronautical Engr.	Chemical Engr.	Civil Engr.	Mechanical Engr.
1	% Yes	23.0	18.5	4.8	26.7
2	Quarter Hours	4	4	(6)*	4
3	Quarter Hours	4	3	3	3
4	% Yes	86.5	61.5	22.8	85.5
5	Quarter Hours	4	3	(4)	3
6	Year	Jr.	Sr.	Sr.	Sr.
8	% Desiring Lab.	92.3	89.6	100	94.6
9	% Yes	63.3	58.3	53.5	74.5
10	% Yes	25.0	8.0	10.7	34.1
Size Sample		16	28	42	48

* Parenthesis indicates very small sample.

Below are listed the first twelve questions of the questionnaire.

1. Do you now require a course in Electronics of your students?
2. If so, how many quarter units are given?
3. How many quarter units of Electronics are available to your students as elective material if not required?
4. Do you desire instruction in Electronics for your students?
5. If so, how many quarter units of required work would you wish?
6. In what year should instruction in Electronics be given?
7. What prerequisite course material would you consider important?
8. Should electronics instruction be accompanied by laboratory work?
9. Do your students receive instruction in alternating current circuits using complex quantities?
10. Do you have any present required work which you would allow to be displaced by instruction in Electronics?
11. If so, what?

TABLE II

Item	Topic	Aeronautical Engr.	Chemical Engr.	Civil Engr.	Mechanical Engr.
		per cent indicating interest			
a	Vacuum tubes	80	66	58	86
b	Rectification	70	53	58	72
c	Amplification	70	53	58	80
d	Oscillators	60	40	42	58
e	Frequency conversion	40	11	9	20
f	Modulation	40	8	9	32
g	Light image production	20	11	4	10
h	Switching circuits	50	32	43	50
i	Counting circuits	50	26	50	42
j	Time measurement	80	45	67	54
k	Time interval generation	30	11	25	24
l	Voltage regulation	70	8	43	48
m	Temperature control	60	21	34	72
n	Temperature measurement	90	29	4	72
o	D.C. power supplies	80	17	34	48
p	Small current measurement	60	42	25	26
q	Voltage measurement	70	45	34	36
r	Frequency measurement	70	80	25	26
s	Displacement measurement	60	16	58	40
t	Thyratrons	60	29	4	60
u	Viscosity measurement	40	71	34	56
v	Pressure measurement	90	74	58	66
w	Induction heating	30	55	43	60
x	Spot welding	20	16	43	44
y	Remote metering	40	32	4	22
z	Pulse generation	0	2	0	4
Size Sample		10	38	13	50

12. Please check the topics in which you would like to see your students receive instruction.

a ..... Vacuum tubes
b ..... Rectification
c ..... Amplification
d ..... Oscillators
e ..... Frequency conversion
f ..... Modulation
g ..... Light image production
h ..... Switching circuits
i ..... Counting circuits
j ..... Time measurement
k ..... Time interval generation
l ..... Voltage regulation
m ..... Temperature control
n ..... Temperature measurement
o ..... D.C. power supplies
p ..... Small current measurement
q ..... Voltage measurement
r ..... Frequency measurement
s ..... Displacement measurement
t ..... Thyratrons
u ..... Viscosity measurement
v ..... Pressure measurement
w ..... Induction heating
x ..... Spot welding
y ..... Remote metering
z ..... Pulse generation

About 70% of the useful replies received were answered by faculty members holding the rank of full Professor including 60% of the total who were department heads. It is possible that if a larger percentage of the questionnaires had been submitted by younger men that the results of survey would have been different though no effort was made to establish the validity of this suggestion.

The results of the answers to the first group of questions are given in Table I. In general these results speak for themselves, enabling the reader to draw his own conclusions. About 17% of the replies indicated required work in Electronics. The given, desired, and available amounts of Electronics work appear to be about 4 quarter units. The Senior year is preferred for such work with about 93% indicating the desirability of laboratory work to accompany lecture work. About 60% of the replies indicate that their students receive instruction in complex quantities. Only 20% indicate present required work that could be displaced by instruction in Electronics.

The results of the topical interest question are given in Table II. Results again speak for themselves. Aeronautical and Mechanical Engineering exhibited the highest interest both in Table I and Table II. Lowest interest was, as might have been expected, exhibited by Civil Engineers.

It is interesting to note that although some 80% of the replies indicate a desire to have Electronics instruction, only 20% are willing to make room for it.

No extensive effort has been made to interpret the results of this survey because of the difficulty of drawing valid conclusions in view of the fact that the questions appear to have experienced a wide range of interpretation. It is hoped that the tabulation of the results will be useful to Engineering Departments in comparing their attitudes with present average attitudes as evidenced by the returns from this survey.

ANNUAL MEETING

UNIVERSITY OF WASHINGTON

June 19–23, 1950 **Seattle, Wash.**

New Members

ABUL-FETOUH, ABDEL-HADI, Lecturer, College of Engineering, Farouk El-Awal University, Alexandria, Egypt. F. M. Dawson, A. B. Bronwell.

ADAMS, LESLIE K., Instructor in Electrical Engineering, University of Kentucky, Lexington, Ky. E. A. Bureau, B. Barnett.

ADAMS, RAYMOND, Instructor in Mechanical Engineering, Villanova College, Villanova, Pa. J. C. Greyson, J. S. Morehouse.

AIKEN, HECTOR H., Instructor in Mechanical Engineering, University of Arizona, Tucson, Arizona. H. H. Armsby, M. L. Thornburg.

ALBACH, WALTER H., Lecturer in General Engineering, University of Southern California, Los Angeles, Calif. R. C. Brinker, H. G. Conley.

ALLEN, FRANCIS P., Librarian and Professor of Bibliography, Rhode Island State College, Kingston, R. I. J. C. Albright, E. M. Pease.

ALLEN, SHIRLI C., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

AMBROSIO, ALPHONSO, Associate in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

BARNES, JAMES C., Assistant Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn. P. A. Cartwright, L. C. Caverley.

BECKMAN, BERTHA, Administrative Assistant, College of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

BENEDICT, RUSSELL H., Assistant Professor of Agricultural Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, K. Engler.

BEZBATCHENKO, MICHAEL, Instructor in Mechanical Engineering, University of Akron, Akron, Ohio. E. R. Wilson, F. S. Griffin.

BEZIK, MAX J., Instructor in Chemical Engineerng, Tri-State College, Angola, Ind. C. E. Shaw, R. W. Gilchrist.

BIRNIE, HANS F., Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. B. M. Green, L. S. Jacobsen.

BLASCHKE, ALFRED C., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

BOTKIN, KENNETH E., Instructor in General Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, J. H. Porsch.

BRENNER, ROBERT, Associate in Engineering, University of California, Los Angeles, Calif. W. P. Wallace, C. M. Duke.

BRODT, ERNEST M., Head, Construction Industries Course, Ohio Mechanics Institute, Cincinnati, Ohio. A. B. Bronwell, P. K. Johnston.

BROMBERG, ROBERT, Associate in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

BROWN, IRA D., Assistant in Research, Industrial Engineering Dept., University of Florida, Gainesville, Fla. E. P. Martinson, J. E. Johnson.

BROWN, LELAND H., Associate Professor of Electrical Engineering, Stanford University, Stanford, Calif. B. M. Green, F. E. Terman.

BROWN, STANLEY R., Instructor in Electrical Engineering, University of Minnesota, Minneapolis, Minn. P. A. Cartwright, O. A. Becklund.

BURNS, STANLEY S., Assistant Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. A. A. Nims, F. A. Russell.

BUSH, ALBERT F., Assistant Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

CALHOUN, JOHN C., JR., Professor and Chairman, Petroleum Engineering Dept., University of Oklahoma, Norman, Okla. R. V. James, W. H. Carson.

CASEY, EDWARD J., Instructor in Electrical Engineering, University of Minnesota,

Minneapolis, Minn. P. A. Cartwright, O. A. Becklund.

CHAIKIN, PHILIP, Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, N. Y. F. W. Ming, J. N. Macduff.

CLARK, EDWARD L., President, Multnomah College, Portland, Oregon. A. B. Bronwell, D. E. Deyo.

CLAUSEN, JOHN N., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. O. W. Potter, H. C. T. Eggers.

CLEMENTS, DONALD F., Instructor in Electrical Engineering, University of Delaware, Newark, Del. D. L. Arm, F. Zozzora.

CLEVELAND, ROGER M., Assistant Professor of Agricultural Engineering, University of Arkansas, Fayetteville, Ark. K. Engler, G. F. Branigan.

COGBURN, CECIL O., Instructor in Mechanical Engineering, University of Arkansas, Fayetteville, Ark. J. G. Gleason, G. F. Branigan.

COLES, FRANC, Administrative Assistant, College of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

CORNET, ISRAEL I., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, C. F. Garland.

COURTNEY, GEORGE W., JR., Assistant Professor of Chemical Engineering, Lafayette College, Easton, Pa. M. King, F. W. Smith.

CROMWELL, LESLIE, Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

DERMER, RICHARD D., Chairman, Electrical Engineering Dept., Indiana Technical College, Fort Wayne, Ind. I. A. Planck, C. M. Cook.

DILLAWAY, ROBERT B., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. J. R. Fellows, N. A. Parker.

DILLON, JOHN C., Lecturer and Principal, Engineering Extension, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

DINNING, JOHN R., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

DUVALL, MELVIN G., Instructor in Chemistry, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, J. T. Faig.

EATON, PAUL C., Associate Professor of English, California Institute of Technology, Pasadena, Calif. F. Thomas, F. Strong.

EHRHART, RUSSELL R., Industrial Coordinator, Fenn College, Cleveland, Ohio. D. C. Fabel, M. B. Robinson.

EUBANKS, JOHN M., Assistant Professor of Electrical Engineering, University of Miami, Coral Gables, Fla. F. B. Lucas, J. H. Clouse.

EVANS, FREDERICK P., Assistant Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. H. L. Kipp, H. L. Daasch.

FARRAR, GERALD L., Assistant Professor of Chemical Engineering, Texas A. & M. College, College Station, Texas. F. F. Bishop, R. P. Ward.

FELLINGER, ROBERT C., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. H. J. Stoever, A. B. Bronwell.

FERGUSON, JAMES E., Assistant Professor of Agricultural Engineering, University of Arkansas, Fayetteville, Ark. G. W. Steinbruegge, G. F. Branigan.

FINCH, VOLNEY C., Professor of Mechanical Engineering, Stanford University, Stanford, Calif. F. E. Terman, B. M. Green.

FLECKENSTEIN, EDWARD L., Instructor in Physics and Electricity, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, J. T. Faig.

FREY, GEORGE J., Head, Mechanical Drawing and Design Dept., Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, J. T. Faig.

GEORGIAN, JOHN C., Associate Professor of Mechanical Engineering, Washington University, St. Louis, Mo. F. A. Berger, R. R. Tucker.

GEPPERT, DONOVAN V., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, W. B. Stiles.

GERLOUGH, DANIEL L., Assistant, Engineering Dept., University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

GIBSON, GEORGE W., JR., Engineer, Marine and Industrial Engineering, Chrysler Corporation, Detroit, Michigan. G. A. Hendrickson, H. L. Byerlay.

GOURRICH, GEORGE E., Mathematician, Bureau of Standards, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

GRANNEMANN, WAYNE W., Instructor in Engineering, Arkansas Polytechnic College, Russellville, Ark. A. S. Turner, A. B. Bronwell.

HADLOCK, CLAY, Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

HANCOCK, GEORGE W., Electrical Coordinator, Cooperative Training, Fenn College, Cleveland, Ohio. D. C. Fabel, M. B. Robinson.

HARTMAN, DAVID K., Instructor in Electrical Engineering, University of Minnesota, Minneapolis, Minn. P. A. Cartwright, L. T. Anderson.

HEHNER, LEONARD A., Advertising and Sales Promotion Manager, American Lead Pencil Company, Hoboken, N. J. L. O. Johnson, I. Wladaver.

HOLLAND, WAYMAN A., Lecturer in Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pa. E. O. Lange, R. C. Disque.

HORBLIT, WILLIAM, Fellow, Petroleum Engineering Dept., Colorado School of Mines, Golden, Colo. R. T. Phelps, F. F. Clark.

JARAND, LEON N., Professor and Head, Electrical Engineering Dept., Chicago Technical College, Chicago, Ill. C. L. Richards, W. Bachrach.

JOHNSON, ALBERT M., Assistant Professor of Physics, Evansville College, Evansville, Ind. J. F. Sears, M. C. Bishop.

JOHNSON, DAVID E., Instructor in Civil Engineering, University of Vermont, Burlington, Vt. J. A. Root, H. M. Smith, Jr.

KADALA, ROBERT J., Instructor in Civil Engineering, Catholic University of America, Hyattsville, Md. H. P. Gallogly, F. A. Biberstein.

KAUFMAN, MURRAY, Assistant, Engineering Dept., University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

KING, E. HARRISON, JR., Principal Laboratory Assistant, Part-time Lecturer, Engineering Dept., University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

KING, SHERWOOD, Assistant Professor of Electrical Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, R. T. Brown.

KIPPENHAN, CHARLES J., Assistant Professor of Mechanical Engineering, Washington University, St. Louis, Mo. H. E. Grant, J. E. Senne.

KLEINHENZ, WILLIAM A., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. O. W. Potter, A. B. Bronwell.

KNAPP, RALPH M., Coordinator, Cooperative Training, Fenn College, Cleveland, Ohio. D. C. Fabel, M. B. Robinson.

KOCK, PAUL O., Instructor in Physics, Ohio Mechanics Institute, Cincinnati, Ohio P. K. Johnston, J. T. Faig.

KONZO, SEICHI, Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. N. A. Parker, J. H. Potter.

KUSIAN, ROSS N., Lecturer in Mechanical Engineering, University of Utah, Salt Lake City, Utah. P. J. Waibler, W. J. Cope.

LAUGHTER, CLYDE N., Assistant Professor of Civil Engineering, University of Delaware, Newark, Del. D. L. Arm, F. Zozzora.

LEBELL, DON, Assistant Engineer, Engineering Dept., University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

LEY, B. JAMES, Assistant Professor of Electrical Engineering, New York University, New York, N. Y. H. Torgersen, J. S. Smith.

LONG, DEAN, Vice-President and Director, Adult Education, Evansville College, Evansville, Ind. J. F. Sears, A. B. Bronwell.

LOOK, FREDERICK W., Assistant Professor of Civil Engineering, Youngstown College, Youngstown, Ohio. G. A. Marston, L. A. Deesz.

LOOMIS, CHARLES K., JR., Instructor in Electrical Engineering, Detroit Institute of Technology, Detroit, Mich. T. G. R. Eynon, A. B. Bronwell.

LUCITTE, EARNEST A., Instructor in Mathematics, Detroit Institute of Technology, Detroit, Mich. T. G. R. Eynon, A. B. Bronwell.

MACFARLANE, CARL S., Instructor in English-Personnel, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, J. T. Faig.

MARSEL, CHARLES J., Assistant Professor of Chemical Engineering, New York University, New York, N. Y. D. B. Porter, A. B. Bronwell.

MARSH, EDWARD H., II, Instructor in Civil Engineering, University of Connecticut, Storrs, Conn. C. J. Pelletier, W. J. Widmer.

MARTIN, WILLARD J., Assistant Professor of Chemistry, South Dakota School of Mines, Rapid City, S. D. G. G. Osterhof, C. E. Schilz.

MARTIN, WILLIAM L., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

MAY, JOHN R., Instructor in Mechanical Engineering, Iowa State College, Ames, Iowa. H. M. Black, H. J. Stoever.

MCCABE, BASIL, Instructor in Electrical Engineering, Lafayette College, Easton, Pa. J. E. Rush, F. W. Slantz.

MCNEAL, XZIN, Assistant Professor of Agricultural Engineering, University of Arkansas, Fayetteville, Ark. K. Engler, G. F. Branigan.

MESSER, ROWLAND E., Instructor in General Engineering, University of Washington, Seattle, Wash. F. M. Warner, R. Q. Brown.

MOSHER, RICHMOND P., Instructor in Industrial Chemistry, New York State Institute, Buffalo, N. Y. E. R. Billings, R. R. Dry.

MOUNT, GEORGE E., Assistant Professor of Psychology and Engineering, University of California, Los Angeles, Calif. H. M. Case, C. M. Duke.

NELSON, HERBER C., Instructor in Engineering, University of Minnesota, Duluth Branch, Duluth, Minn. Thorndike Saville, A. B. Bronwell.

NIEBEL, BENJAMIN W., Instructor in Industrial Engineering, Pennsylvania State College, State College, Pa. A. B. Bronwell, R. S. Farwell, Jr.

NIELSEN, JOHN P., Associate Professor of Metal Science and Chemical Engineering, New York University, New York, N. Y. J. Happel, D. B. Porter.

NURNBERGER, PAUL A., Professor of Physics, Detroit Institute of Technology, Detroit, Mich. T. G. R. Eynon, L. L. Henry.

O'BRIEN, PHILLIP F., Assistant in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

O'BRIEN, ROBERT J., Instructor in Engineering, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, J. T. Faig.

ORNSTEIN, WILHELM, Associate Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. G. B. Thom, J. H. Pitman.

PALEVSKY, GERALD, Instructor in Civil Engineering, New York University, New York, N. Y. R. L. Lewis, A. B. Bronwell.

PARKER, JOHN, Instructor in Mechanical Engineering, University of Connecticut, Storrs, Conn. F. L. Castleman, Jr., C. H. Coogan, Jr.

PELAN, BYRON J., Instructor in Mechanical Engineering, Lafayette College, Easton, Pa. J. E. Rush, A. B. Bronwell.

PIERCE, GEORGE O., Associate Professor, School of Public Health, University of Minnesota, Minneapolis, Minn. T. L. Joseph, J. J. Ryan.

PINGER, ROLAND W., Lecturer in Mechanical Engineering, University of California, Berkeley, Calif. H. B. Gotaas, C. T. Wiskocil.

RANKIN, ROLFE M., Professor of Mathematics, Missouri School of Mines, Rolla, Mo. C. L. Wilson, R. Z. Williams.

REHBERG, CHARLES F., Associate Professor of Electrical Engineering, New York University, New York, N. Y. S. G. Lutz, G. Calabrese.

RICHARDS, ALVIN M., JR., Assistant Professor of Civil Engineering, University of Akron, Akron, Ohio. E. R. Wilson, F. S. Griffin.

RICHARDSON, RICHARD L., Assistant Professor of General Engineering, Oregon State College, Corvallis, Ore. R. A. Wanless, E. C. Willey.

ROBLEY, GRANT, Assistant Professor of Civil Engineering, Yale University, New Haven, Conn. Thorndike Saville, A. B. Bronwell.

ROSENSTEIN, ALLEN B., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

RYERSON, JOSEPH L., Assistant Professor of Physics, Evansville College, Evansville, Ind. J. F. Sears, A. B. Bronwell.

SALTZ, FRED, Assistant Professor of Machine Design, Cornell University, Ithaca, N. Y. A. H. Burr, H. H. Mabie.

SCHINDLER, TURFIELD D., President, Lower Columbia Junior College, Longview, Wash. D. E. Deyo, A. B. Bronwell.

SCHNEIDER, CHARLES S., Assistant to Director, Research Division, College of Engineering, New York University, New York, N. Y. H. K. Work, Thorndike Saville.

SCHMIDT, ALOIS X., Assistant Professor of Chemical Engineering, City College School of Technology, New York, N. Y. W. Allan, G. E. White.

SCHOFIELD, WENTWORTH H., Assistant Professor of Mechanical Engineering, University of Maine, Orono, Me. P. Cloke, H. D. Watson.

SCHULTZ, CLARENCE W., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. L. E. Williams, R. L. Laudenslager.

SCRIVNER, CHARLES AL., Instructor in Engineering, Marshall College, Huntington, W. Va. S. T. Stinson, E. S. Maclin.

SELLS, JACKSON S., Instructor in Electrical Engineering, University of Miami, Coral Gables, Fla. C. E. Anderson, H. H. Sheldon.

SMYTH, WILLIAM I., Professor of Metallurgy and Mining, University of Nevada, Reno, Nev. J. A. Carpenter, S. G. Palmer.

SOWERS, OSSA R., Instructor in Design, Brooklyn College, Brooklyn, N. Y. A. N. Guthrie, W. Allan.

STANLY, ALBERT L., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

STEINBRUEGGE, GEORGE W, Associate Professor of Agricultural Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, K. Engler.

STEWART, PAUL B., Assistant Professor of Chemical Engineering, University of Southern California, Los Angeles, Calif. D. M. Wilson, R. C. Brinker.

STONE, ORVILLE N., Instructor in Mechanical Engineering, Fenn College, Cleveland, Ohio. S. M. Spears, N. R. Rimboi.

TERRELL, CARROLL F., Instructor in English, University of Maine, Orono, Me. P. Cloke, C. E. Bennett.

TRAUTMAN, DEFOREST L., JR., Assistant Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

TUCKER, ROBERT E., Instructor in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

URIAN, GEORGE G., Instructor in Engineering, Marshall College, Huntington, W. Va. S. T. Stinson, E. S. Maclin.

VAN VLIET, JAMES L., Instructor in Physics, Lawrence Institute of Technology, Detroit, Mich. G. A. Hendrickson, G. P. Brewington.

VARNEY, WILBUR R., Assistant Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif. D. S. Clark, D. E. Hudson.

VATER, GERHARD A., Instructor in Electrical Engineering, University of Minnesota, Minneapolis, Minn. P. A. Cartwright, D. E. Jansen.

WATSON, VERNON C., Instructor in Tool Engineering, Sinclair College, Dayton, Ohio. R. D. Lane, R. C. Klas.

WHITE, DAVID C., Associate Professor of Electrical Engineering, University of Florida, Gainesville, Fla. H. E. Schweyer, N. C. Ebaugh.

WILKERSON, ROBERT T., Lecturer in Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

WILLIAMS, ELBERT E., Instructor in Applied Mechanics, University of Kentucky, Lexington, Ky. S. F. Adams, R. D. Hawkins.

WOODY, GUY V., Manager, Basic Industries Mach. Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis. F. T. Agthe, B. G. Elliott.

YUSTER, S. T., Professor of Engineering, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

564 New members this year.

Editorial—ASEE Activities for Young Engineering Teachers*

By FRANK L. SCHWARTZ

Associate Professor of Mechanical Engineering, University of Michigan

There appears to be a need in the Society for an organization in which the younger members of the engineering teaching profession can find assistance, expression and responsibility in the advancement of themselves and the Society. A high percentage of the membership of the Society consists of teachers in the lower academic ranks.

In April, 1949, President Freund appointed an interim committee to explore areas of interest and organize sessions, conferences and other activities specifically for younger members of the ASEE. President Saville reappointed this committee for 1949–50. This committee selected the name "Committee for Young Engineering Teachers," set up a limitation of 35 years of age, or a rank below Associate Professor on the eligibility of members of the Society in the work of this activity, and defined the objectives of the group which are:

A. An understanding of the general goals and responsibilities of the *two* professions which every teacher of engineering follows, engineering and education.

B. Orientation into the history, the lore and the "unwritten laws" of the dual profession of engineering education.

C. An acquaintance with the most effective instructional materials and methods, with methods of evaluating student achievement and with the elements of counseling and student guidance.

D. Guidance in his personal professional development both as an engineer and as a teacher.

E. A means of exchanging ideas with his contemporaries.

F. Stimulation.

G. Dissemination of knowledge.

The Executive Board of the Society has provided two sessions for young engineering teachers at the Annual Meeting at the University of Washington. The first session will be devoted formally to organizing the younger members of the Society into an active organization and the second session will be a technical one.

It is hoped that at least one or more teachers from each school who are eligible in this group will be able to attend the University of Washington Annual Meeting. College administrators can assist by providing funds in part or total toward expenses so that interested young teachers may be able to combine a pleasant vacation with a worthwhile project.

If sufficient interest develops among the younger teachers, this group should apply for Division status in due time.

COMMITTEE FOR YOUNG ENGINEERING TEACHERS
J. F. BAILEY
O. P. BERGELIN
F. R. STEINBACHER
C. R. VAIL
F. L. SCHWARTZ, *Chairman*

* This issue of the JOURNAL contains articles of particular interest to younger faculty members.

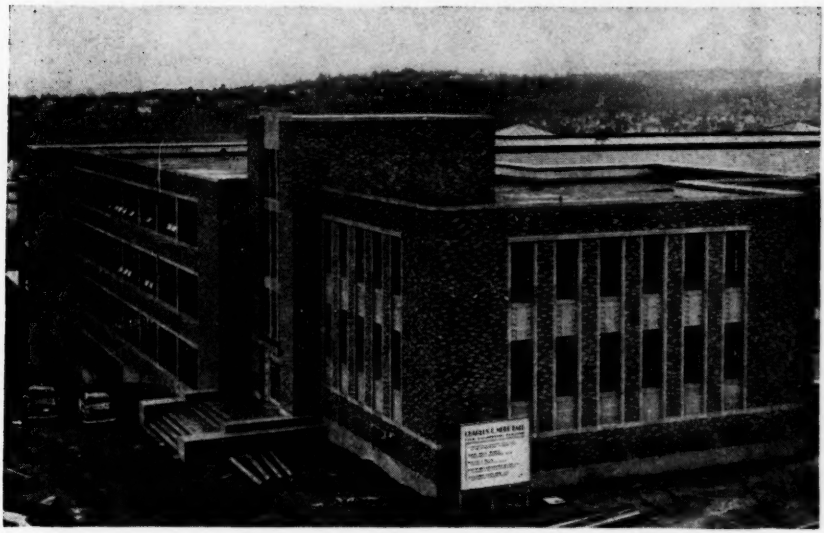
University of Washington Host for Annual Meeting June 19–23, 1950

Fringing twenty-mile long Lake Washington, the College of Engineering of the University of Washington is about to celebrate its first fifty years on the campus of the University of Washington. The dynamics of western development, plus the role of technology in relation to the tide of world economic and political pressures, have energized the growth of the College of Engineering from its figurative microscopic beginning in 1902, with a Dean and one other instructor as the nucleus of the department of Civil Engineering, to its present position with a faculty numbering 135 graduates from the outstanding universities of the country. 1700 Engineering students, over 1/10th of the total enrollment in the university, were registered in the College of Engineering in 1949.

In order that space be made immediately available following World War II, the University channeled several million dollars to provide new and efficient facilities. Two large buildings have been completed, each at a cost of over one million dollars. The present progress of construction is about 40% of the planned building program. Thus far the departments of Civil and Electrical Engineering have been provided with excellent working facilities. Hence, at present the departments of Mining, Aeronautical, Chemical, Electrical, and Civil Engineering have adequate plants of their own with the Mechanical Engineers to be provided for in the near future.

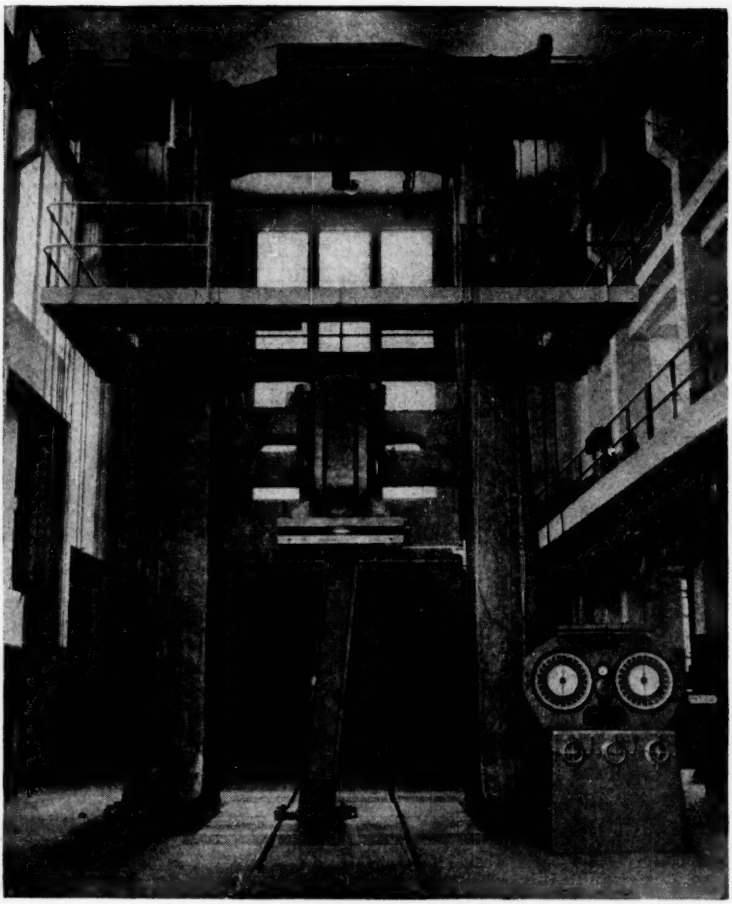
Although the College of Engineering has, in its entire history, accented the fundamentals of Engineering, it has juxtaposed with this basic aim a spirited program of research. Many research activities are now coordinated through the Engineering Experiment Station under the supervision of a director and a council composed of representatives of research from each department. For example, the department of Aeronautical Engineering contributed all the wind-tunnel research for the B-17 and approximately 60% for the B-29 as well as the first Boeing Strato Cruiser. The department of Civil Engineering has likewise been involved in a major research project. The Federal Government, the Washington Toll Bridge Authority, and the University, following the collapse of the Tacoma Narrows Bridge, authorized and financed the building of a laboratory and scale model of the Bridge. The linear scale of the model is 1′–50′. The laboratory was built at a cost of approximately $30,000, the roof and sides constructed in a semi-eliptical form in order to allow 10 fans to create relative wind velocities up to 118 m.p.h. Over $100,000 has been spent on this project thus far.

The research program, augmented by planned field trips and summer employment in various factories, foundries, power dams, as well as Alaskan Civil and Mining Engineering developments that consistently afford summer employment for students, have combined to provide a practical basis of experience that has generated a type of high caliber graduate sought by leading industrial organiza-



The new Civil Engineering Building as it nears completion in the summer of 1947.

The new Electrical Engineering Building, completed and equipped in 1949.



Photos by James O. Sneddon

This new hydraulic electric testing machine, the second largest in the world, capable of generating a force of 2,400,000 lbs., is testing an eccentrically loaded column in one of the laboratories in the Department of Civil Engineering's new building, More Hall.

tions. In addition to this, the State of Washington and private grants have established scholarships through which the development of the states resources and industries are actively promoted.

In order that the students program be thoroughly rounded out, the College of Engineering has taken pride in its work in the humanities. Although the Humanistic-Social Department has been officially recognized as such for only three years, as far back as 1920 an instructor was provided from the English Department to break ground for what is now a department with a staff of 11 instructors. The College of Engineering has always been cognizant of the fact that the slide rule, for all its capacities, cannot compute the unknown quantity in the human equation.

Human Relations in Engineering Education*

By T. KEITH GLENNAN

President, Case Institute of Technology

I was happy to accept your invitation to speak at this meeting because the subject under discussion is one that first interested me when I was but one year out of college. Having been trained as an engineer, I found myself shortly after graduation faced with the task of recruiting a work force of engineers in a foreign country, training them in a new field and with equipment which was completely alien to their experience, and responsible for operations over a wide area of technical and business activity. Believe me, I began to think seriously, even then, of the voids in my own educational experience. Many years in industry, often with responsibility for hiring and training graduate engineers, merely served to strengthen my convictions that the engineer needed more than a technical education. Leaving industry eighteen months ago to head an engineering college brought me face to face with the situation about which I had complained, but for which I had heretofore no responsibility. Thus, the discussion of human relations means more than mere mental exercise to me.

As we approach the study of human relations and its place in the institution for technological education, let us first examine the reasons for feeling that a knowledge of human relations is of particular importance to the engineer, and then suggest and discuss methods whereby the engineering student may be instructed in this field. Just now the woods are full of educators, like myself, who are tossing around terms such as—let us teach the student how to live and not merely how to make a living—let us train men and not just engineers—let us educate the man as a whole and not just the mind. These are interesting catch phrases of the slogan type, but they lack the specific quality which we need for a serious analysis of the subject to which they relate..

Values Deserving Emphasis

What are the values that we are seeking to emphasize in teaching human relations to engineering students? I would suggest three general classifications—values for the individual, values for society, and values for industry. Naturally, these classifications, or fields of values, will overlap to some degree.

For the student as an individual, we may seek the same catalog of values and benefits which have long been the objectives of a general liberal education. The Harvard Report on General Education in a Free Society lists the following abilities as the aims of general education—"effective thinking, communication, the making of relevant judgments and the discrimination of values." If the college succeeds in these aims, the graduate as an individual will have a sense of adequacy and a sense of purpose. Such an educational experience should fit him as an individual to be at ease in his social contacts, should give him the urge to keep himself informed adequately concerning the developments of his own times, and should give him a sense of his own worth and his place in the general pattern of society. The individual who acquires this subtle and hon-

* Presented at the Ohio Section Meeting, Athens, Ohio, April 9, 1949.

est recognition of his own value inevitably will have an interest in and responsibility toward his fellow man.

Great as are these values to be sought for the individual in the study of human relations, the advantages which this addition to engineering education offers to society are even more important. Our present highly industrialized world community has made necessary an increased sense of social responsibility on the part of everyone.

In the wider reaches of public obligation and moral responsibility, which we commonly refer to as civic leadership, the true professional man of whatever discipline must live by the rule that noblesse oblige. Our times serve to emphasize this phase of our responsibility also. On the educated man, on the citizen whose status gives him stature, rests a special charge to uphold his democratic ideals against all dictatorial challenge. On those who know and can express themselves effectively rests the obligation to teach the truth about our economic system to the many who have had less opportunity to learn.

If the engineer is to accomplish this objective, he must know the ideals and traditions of the American way. He must be grounded in its history and in its political and economic philosophy. He must know, for example, that American capitalism is not, as the Leftists assert, merely an extension of European capitalism. He must know that unlike the European system which guarantees the right of property, our system was conceived in full appreciation of the individual citizen and of human values so that under our interpretation of capitalism as expressed in the Declaration of Independence, the guarantee is that of "The Pursuit of Happiness." In summary, to defend his way of life, the engineer requires a knowledge of the roots of its philosophy.

Professional Responsibilities

The layman speaks of putting his life in the physician's hands. Probably he has never thought that even more frequently in his everyday activities, his physical well being—yes, even his continued existence—depend on the integrity and careful work of the professional engineer. Modern man's high speed transportation and his host of mechanical and electrical luxuries become his destroyers if either the engineer's skill or his devotion to the highest standards of service falter.

Or, the engineer's public responsibility may be compared with that of the attorney. His decision on the value of a new productive process, if tainted by self interest, by carelessness, by failure to keep abreast of the times, may be as damaging as a like faulty judgment by the firm's legal department. In the wake of either failure rides loss for stockholders, uncertainty of employment for labor, and strain on the total economy.

The education of the engineer and his training in the skillful handling of human relationships have a special significance for society in our era when science and technology, over which the engineer and scientist have mastery, have become matters which affect so critically the daily life of all mankind. Chairman David E. Lilienthal of the U. S. Atomic Commission has made that point strikingly clear in his recent address entitled, "Science and the Spirit of Man." Mr. Lilienthal contends that the issue with which all peoples of the world will be at grips constantly for the rest of their lives is this, "Are machines and science to be used to degrade man and to destroy him, or are they to be used to augment the dignity and nobility of mankind?" This, Mr. Lilienthal characterizes as, "The struggle of our time." Pointing out that "the machine and technology are neither good nor evil in themselves" but are only so as man uses them for good or evil, Mr. Lilienthal contends that "the machine can be so used as to make men free as they have never been free before." All these things being true, Mr. Lilienthal sees a vast and critical importance in the type

of person who directs the applications of research and technology.

Says he, "The guiding of technical activities is safe in terms of the human spirit, only when it is in the hands of those, in private business and in public agencies, who have faith in the individual human being."

I have attempted here no exhaustive statement of the social values which may be created out of the engineer's study of human relations, but have sought merely to point out highlights which seem typical of the advantages which we should seek. Nor in discussing the benefits to be sought for industry, and for the engineer as a participant in industry, can we take time for a complete catalog. Rather, let us note two important areas of values for industry and for the engineer as a servant of industry. One value of such study is the aid which it gives the engineer in dealing with an industrial problem as a whole with consciousness of its various parts and of their inter-relationships. The engineer may not be interested merely in the mechanical performance of a proposed new piece of industrial equipment. He must consider it with respect to its integration with the entire production process. He must be cognizant of its meaning for the economy of his firm. He must evaluate its usefulness in terms of possible personnel problems and, in the case of many types of installation, even in terms of community interests and reactions. As we see the engineer moving into the areas of economic, personnel and community problems, his need for education in human relations stands out crystal clear.

Human Relations—Our Worst Mismanagement

Finally, in this examination of some of the more important values for industry, we need to confront the fact that in its use of the three fundamentals of industry —men, money and materials—management has done its least effective job by far with the first. We cannot get away from the fact that in the handling of manpower either at the level of the hourly rated worker, of the supervisor, or of the junior executive, industry has for years miscalculated and instead of taking the lead in developments at these various personnel levels, it has been continually forced to accept the dictates of government, or organized labor and of the exigencies of the hour. Collective bargaining and governmental regulation in general have taken over the initiative from management.

At the higher levels there is ample evidence of weak industrial planning through lack of vision and appreciation of industry's stake in education. Management, by and large, must rely today on the relatively unschooled foreman risen from the ranks of labor. Too frequently this type of supervisor proves inadequate when confronted with the complexities of modern industrial organization. At the management level itself we find today the bad fruits of the false economy efforts of the 1930's when few well educated engineers were being hired as junior executives.

Most critical of management's many current problems in human relations is the now all-too-obvious fact that labor puts its confidence in professional union leadership rather than in management and that the employee takes the advice of union leadership in preference to that of management. The engineer of the future who has been educated on the assumption that the know-how of his profession includes the know-how of human relationships as well as slide rules and formulae is one of industry's greatest hopes for regaining lost leadership in its handling of men. Here are prospective values indeed!

But how are these values from the study of human relations to be attained for the individual, for society, and for industry? One would not be dogmatic in reply to this question. Engineering education is still essentially at the theory stage in its effort to bring to its students an adequate coverage of human relations. We must try many ideas, record and consider data, and try over again before we shall have

arrived at any satisfactory formula. The important element, too often missing in education, is the willingness to undertake experimentation.

Granted, however, that we are ready and eager to experiment with the development of these human relations values we must search for the answers to at least three basic problems. First, what content should be presented to the engineering student for his development in the field of human relations? Second, how shall this content be fitted into the program for the engineer's education? Third, how shall the content be organized for the engineering student?

One of Alexander Pope's often quoted lines sets forth a truth that points the way toward the content in which we are interested. Wrote the poet, "The proper study of mankind is man." Pope's statement leads us, however, to the further question—how may we study man? The answer is, that we study him through the records which he has left, his literature, his history, his economic, social, political and philosophical theories. Man fortunately has the ability to accumulate knowledge from generation to generation, an ability granted to no other living organism. Further, history shows us that man faces the same problems in every age and is thus enabled to interpret the present through an understanding of the past. These facts and principles then point the way to the type of content with which our study of human relations must be concerned.

Exposition of Humanities and Social Science Subjects

But how shall the engineering student be exposed to a knowledge in these fields of the humanities and the social sciences? Shall he be required to spend one, or perhaps two, years in study of these subjects preparatory to entering the engineering college? Or, shall this subject matter be crowded into the first one or two years of the curricula of such colleges? Or, as a third choice, shall this study run throughout his engineering course concurrent with his training in technical areas?

Traditionally, the humanistic-social courses have paralleled the technical courses in each year of the college program. The difficulty encountered in this plan, however, is that the two types of courses normally remain parallel and that seldom, if ever, in the process of instruction do they meet and achieve a useful synthesis. Our task then is to find out how to effect an integration of these two major facets in our educational field. Economics, for example, should not be kept in its separate compartment in the curricula. Instead, it should be so presented as to make clear to the student the impact of economic facts upon his engineering problems and vice versa. The great merit of having the humanistic-social courses taken concurrently with the engineering courses throughout the curriculum leading to the bachelor's degree is that it affords opportunity for the development of the relationship of these two types of content, if we will but make that relationship a living one.

The faculty must assume what Ordway Tead, Chairman of the Board of Education of New York City, has called "The Obligation of Relatedness." Facts and ideas in themselves are inert until their relationships are made clear to the student. A student must be brought to realize, not only the relationships existing between the facts and ideas which he is studying, but also their bearing upon the problems which he must meet as an engineer. Further, the instructor must continually make it clear that what is being studied matters. Not only must the importance of the material to the engineer be explained, but the reasons for its significance must be put before the student as well. With their relatedness made clear, the humanistic-social elements of the curriculum cease to be mere requirements to be completed for graduation and become realities in the preparation for the profession of engineering.

The success of this plan of curriculum

organization and, in fact, success of all the instruction in the area of human relations, depends, in the final analysis, upon the cooperation of the faculty members who teach engineering courses. Without their support and without their earnest efforts to relate the humanistic-social materials to the content of their own technical courses, student interest will not be adequately stimulated in the studies that bear on human relations.

In organizing this content for the engineering student, we may well avoid departmentalization. American higher education has bowed down too long and too much before this false idol of departmentalization and has offered unto it far too many sacrifices of instructional efficiency. Engineering colleges face problems of unusual difficulty in the building of their curricula. So rapid has been the advance of science, so great has been the accumulation of technological knowledge, that it is impossible to condense it all within the confines of a four-year, or even a five-year program. When, in addition to this engineering content, we attempt to crowd into the program an adequate study of human relations a bad problem is made worse. The only answer to this problem can be found in efficiency of instruction. Traditional departmental lines must be crossed and forgotten. Streamlined courses, carefully shaped to the particular needs of the engineering student, must draw their content from a wide range of departments with a minimum of regard for traditional approaches to the subject matters involved. Only thus can we avoid the danger that our curricula may become devices for teaching students less and less about more and more.

Implementation of Ideas

Let us take a moment now to note how the three experimental answers we have outlined may be applied in a specific engineering school program. Let us start the prospective engineer off in his freshman year with a course we have just put into our first year curriculum at Case Institute—a course entitled "The Background of American Democracy." This course will cut across many departmental lines to bring before the freshman student a picture of the American way of life and an explanation of the processes through which it has developed. The course will draw upon the materials of history, government, literature, economics, sociology and psychology to portray and explain the full sweep of American life.

A freshman course of the type just described might well be followed in the sophomore and junior years by an integrated two year course, "The Background of Western Civilization." Here again, the course should black out all narrow departmental confines so that it may bring to bear every discipline and every factor that has made an impact on the mind of man, having as its ultimate objective, supplying the student with a knowledge of the accumulated wisdom and the common problems of man through the ages. It would delve into economics, history, literature, the arts, science and politics. Aiming again at the particular needs of the engineering student, it would trace most carefully step by step through the ages the effects of the developments of science and industry upon the life of man. As the course came to its focus at the close of the junior year, it would present to the student as complete a picture as possible of the place of the scientist and the engineer in the modern world, delineating the opportunities and the responsibilities entailed.

Then, to complete the stream of humanistic-social studies throughout the entire curriculum, a senior would be given an opportunity to choose among a limited number of electives in international relations, music, art, and literature. Only in these senior year courses does this plan make use of the conventional type of course offered within the departmental framework.

In essence, what I have been saying is that there are many values for the individual, for society, and for industry to be

had from the education of the engineer in human relations, but that the means for their realization are now at the experimental stage. Currently, the most profitable type of experiment seems to be that of selecting materials from the humanities and social sciences without regard to departmental lines for presentation to students in a continuous sequence throughout the college course with special emphasis on the relatedness of the content to the work of the engineer. Instruction in human relations is today's frontier in engineering education. Its exploration requires the courage and the far vision of the pioneer.

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What Is Good Teaching?

By H. P. HAMMOND

Dean of Engineering, Pennsylvania State College

This is a question to which a vast amount of thought and discussion has been devoted for many years. To hazard a single-sentence answer to it is, of course, artificially to simplify a very complex matter, yet in engineering I believe the answer is this:

Good teaching is the development of the student's ability to do things for himself.

The fundamental quality that every engineer must possess is the ability to do and to create. Any teaching process that does not develop this capacity fails of its purpose. It is true, of course, that teaching, whether in engineering or in other fields, must also accomplish other ends: acquisition of knowledge; development of the capacity to learn; acquirement of an appreciative sense of the appropriate way to do things; development of a sense of beauty in a product; and so on. These aims of teaching cannot be belittled, but in engineering they are subordinate to the main objective of developing the ability to accomplish things for oneself.

This answer to the question is not, of course, a complete one, but merely leads up to the further question of *how* teachers can aid students to acquire the ability to accomplish. To answer this question in turn involves discussion of all aspects of the teaching process. What follows is an attempt to deal briefly with one or two of these.

The writing of this article was prompted by two incidents that came to my attention recently. One was a comparative tabulation of student opinions about the teaching of two sections of a class by different teachers but from the same text. Opinions about the teaching of one section was highly favorable. In particular it was pointed out that the instructor gave excellent classroom explanations, and, by inference, helped to make study of the subject relatively easy. The other set of opinions, while not critical, pointed out the desirability of more explanations by the instructor. Not having attended the classes, and merely having heard about them, I may not judge accurately, but it appears that the second teacher required the students to rely more on themselves. This is a mark of good teaching, provided, of course, that the students finish the course with a sound knowledge of the fundamentals of the subject, which I believe was the case in this course.

The other instance was in a class in production engineering which requires each student to select an article or device, to design its principal features, and to devise a method of manufacturing it. At the end of the course the students were asked to submit frank opinions about it and to suggest possible improvements. Very interestingly, the students' comments fell into two clearly defined groups. One group expressed great appreciation of the fact that for the first time in their academic careers they had had the opportunity to select their own project and to exercise ingenuity in working it out, a new and revealing experience for them. The other group complained that too often they had to ask for assistance when it was not volunteered. While the first group benefited from the course, I believe that the second group benefited

even more since they began to acquire self-reliance, which is a chief, though unannounced, purpose of the course.

Fundamental Aim of Engineering Education

In the last analysis, then, engineering at professional level consists in essence in creating and doing things on one's own responsibility, and development of this capacity is the fundamental aim of engineering education. The extent to which this is accomplished is the measure of success of our teaching.

How is this to be done? In the first place I believe that we will not develop students' ability to do things for themselves unless we *require* them to do just that. People do not really learn or acquire lasting knowledge by having others do things for them.

I once heard Professor Warren K. Lewis, Lamme Medalist of 1947, say in response to a question as to the basis of his success as a teacher, that his method was to back the student up in a corner, figuratively speaking, and not permit him to escape until he got himself out of it or acknowledged defeat and agreed to come back the next day prepared to succeed. No present day teacher commands greater respect of his students than Professor Lewis, and this is based on the fact that they acquire from him the self-reliance that makes competent and resourceful engineers.

Another illustration: Some years ago there was a small but notable group of engineering teachers at another institution. These men differed greatly in temperament and methods but all were noted in their respective fields. At one extreme was a man whose students spoke of his wonderful facility of expression and ability to explain things in the classroom so that no one left the room without understanding the day's topic. He was popular. At the other extreme was a hard taskmaster, blunt and inclined to ride his students hard. He insisted not only that they think things out for themselves, but that they prove to him they had mastered the principles as they used them. This man was not popular though his students respected him. Ten or fifteen years after graduation his former students looked up to him as the one teacher above all others who had laid the foundations of their success.

These examples do not serve to answer completely the question of what constitutes good teaching, for teaching is largely an individual matter and rests on a complex of personal qualities and conditions, but they may serve in some measure to give the clue to one basic factor of a sound teaching process.

Engineering is Ideal Educational Medium

Engineering lends itself to the development of ability to do things for oneself probably to as great an extent as any other division of higher education, not even excepting medicine which is sometimes considered to come first in this respect. Our whole scheme of education is conducive to that objective. The combination of recitation, laboratory, and design classes, all dealing directly with things to be done and ways of doing them, is an ideal arrangement for learning both the *how* and the *why* of things.

Do we fully realize on the possibilities of this scheme of education? I fear that we do not. In perspective, as I think of my own years of classroom teaching, I am sure I erred, and erred badly, by doing too much for my students, by explaining where I should have induced them to work things out, and by showing them how to solve their problems before waiting to see how they attempted to do them and then, when they were stalled, to help, by a question or suggestion, to find their own solutions. I once exchanged final examination papers in hydraulics with Professor S. M. Woodward, a great teacher, and was much pleased to find, on first sight, that my examinations were more extensive in coverage and more difficult than his. Woodward wrote to me, in fact, that his students would not be able

to pass my examination. As I thought this over, which I did because Woodward was probably the ablest teacher of mechanics and hydraulics in the country at that time, and as I studied his examination closely, the difference between the two papers became clear: Woodward was testing his students' ability to find the comparatively simple fundamental law on which the solution was based and then to employ it in its basic form; while I was testing my students on their facility in the use of derived equations, each applying to a limited set of conditions. From that time on I changed my method and devoted much more effort to making my students more self-reliant, to giving them a better command of fundamental principles, and to making them less bound by the covers of the textbook. It was much harder work on my part and the students did not like it, but I am sure that from that time on they could do more original work in hydraulics than they had been able to do before.

What does this lead to? I hope for one thing it may lead to a fairer appraisal of good teaching, of which students are inclined to be critical when the teacher does not do pretty much everything for them in arriving at an understanding of a subject. I hope also that it may lead teachers to induce their students to a greater degree than at present to seek to learn on their own initiative instead of merely being receptive to the teaching in the classroom. I hope it may direct attention to the need of developing an inquiring turn of mind and, in spite of the heavy load of required work, to have students plan some activity for themselves instead of always following instructions. And the purpose is also to aid in influencing more men to go on to postgraduate work wherein both the required courses and the thesis give opportunity to an increasing degree for the acquirement of self-reliance and the ability to work things out for oneself.

College Notes

As a part of the 1950 Summer Session of the **University of Michigan**, the Department of Electrical Engineering will offer an eight-week specialized Summer Electronics Symposium, presenting visiting lecturers from other universities and from various industrial and governmental laboratories, including representation from England. The Electronics Symposium will run from June 26 to August 18. The lecture and conference program offered will be similar in nature to that of the Electronics Institute held at the University of Michigan as part of the 1937 Summer Session.

Rensselaer Polytechnic Institute announces the organization of its new Department of Fuel Resources. Effective September 1950, courses of instruction and research will be offered to candidates for graduate and undergraduate degrees.

* * * *

Russell P. Harrington has been named the head of aeronautical engineering at **Rensselaer Polytechnic Institute** to succeed Dr. Paul E. Hemke who became Rensselaer's dean of faculty at the opening of this college year. Dr. Harrington assumes his new post on July 1.

Individualizing Engineering Education

By A. PEMBERTON JOHNSON [1]

Formerly Coordinator of Personnel Guidance, Purdue University, Project Director, Testing Projects in Engineering Education, Educational Testing Service

The SPEE Committee on Engineering Education After the War [2] stated in its May 1944 report:

"The purposes and problems of engineering education hinge on its two major responsibilities. One of these, which determines its aims and standards, is to the public, industry and the profession it serves. The other, which determines its methods, is to the students as individuals." It is to the ever-pressing problem of bringing about for each student the greatest possible individual development of mind and character that this paper is directed.

A careful consideration of the matter evokes at least these two basic questions:

(1) toward what goals shall engineering education be individualized? What are the desired individual attributes which we seek to develop?

(2) by what practical means shall we work toward these goals?

Goals

The report of the SPEE Committee on Engineering Education After the War implies broad aims including essentially the specific aims recommended in 1940 by the SPEE Committee on Aims and Scope of Engineering Curricula; to quote:

> They include training in the sciences basic to engineering, the rudimentary development of certain technical skills, an introduction to the engineering method of solving problems of practice, an understanding of values and costs, a sense of the art of engineering as distinguished from its science, the ability to read, write, and speak the English language effectively, a knowledge of social and human relationships, an understanding of the duties of citizenship, an appreciation of cultural interests outside the field of engineering and indoctrination in professional standards and relations. Inherent in the accomplishment of these purposes is the development in the student of habits of accuracy and thoroughness, powers of analysis, creative ability, respect for facts, and high standards of integrity with respect to all aspects of his work.

What a tremendous task lies ahead of the entering student! How many students are informed of these goals early in their engineering college training? How many, once informed, take upon themselves the task of self-education so clearly implied therein?

Daily, the student who is aware of the social forces operating around him finds new evidence of the struggle between the democratic and the totalitarian concepts. President Harvey N. Davis of Stevens Institute of Technology in his address to the Institute's undergraduates at the opening of their 1947 fall term stressed some basic features of this struggle and

[1] The author wishes to acknowledge his deep appreciation to Dean A. A. Potter of Purdue University for constant stimulus to his thinking regarding engineering education.

[2] "Report of Committee on Engineering Education After the War." *Journal of Engineering Education*, 34: 589–594, May, 1944.

set some extremely worthwhile goals. In part, he said: [3]

As I see it, the major problem of the day all over the world is how to get from considerable masses of human beings the kind of day by day action that, in the long run, is most conducive to the welfare of their neighbors, of their communities and, increasingly in these days, of the world as a whole.

There is only one ideal way appropriate to a democracy of securing that necessary internal discipline, that essential volume of socially desirable activity, that we must have. It is through wide-spread, intelligent, effective *self*-discipline imposed by each one of us *on himself*, the kind of self-discipline that makes a man want to do a full day's work for a day's pay, and to do it just as well as he knows how, just as a matter of pride and self-respect.

There was a tremendous amount of this sort of self-discipline among our pioneer fore-fathers.

It is this sort of self-discipline that we are sadly in need of today. It must be intelligent, for each individual must pick for himself the driving urges that dominate his life, and they will be socially desirable only if he himself has read widely and thought deeply about something more basic than his own selfish comfort and prosperity. *This is the great task of education, to give to great numbers of people the knowledge that will lead them to choose activities that will benefit us all.* This self-discipline must also be effective. The emotional urges that motivate it must be strong and satisfying. This can only be the result of high professional ideals, of high standards of workmanship inspired by pride in one's job, by patriotic fervor, or, if you like, by religion in its broadest sense.

Dr. Frank C. Hockema, a Vice-President and the Executive Dean of Purdue University, has stated in his 1947 Study of Higher Education for Engineers [4] that modern engineering education has three objectives:

1. *The Economic Objective.* Engineering education aims to give young men and women the sort of technical, vocational and scientific education which will enable them to perform useful services to society while becoming self-supporting through specialized services to industry, government, and the profession of engineering.

2. *Development of the Individual.* It is the function of engineering education, as of all education, to develop the character, the personality, and the aptitudes of the individual; to strengthen and to improve his habits; to search out his native abilities and inclinations so that these qualities may be developed. An important part of this objective is to give the student every possible assistance in learning how to think; to subject him to every stimulus that can be provided which will awaken his interest and develop his imagination, initiative and skill.

3. *The Social Objective.* The social objective of education is frequently considered the most important, since democracy rests upon the good sense and tolerance of the people. This objective implies the development in each student of an appreciation of the cultural side of life, "human engineering," and an open-minded, cooperative attitude. The right mental attitude is often preferable to great mental capacity; a combination of both is most desirable.

A careful study of the goals proposed by the committees and persons quoted above shows a remarkable agreement, in spite of minor variations. It is the author's belief that earnest discussion of the goals of engineering education by administrative, instructional, counseling and research staff members can bring about close agreement among them as to the broad objectives of their daily efforts. Those who participate in thoughtful discussions of this nature must surely broaden and deepen their own understanding of what they are seeking to accomplish. In their search, the wise guidance of great teachers can be invaluable.

[3] The President's Address at the Opening of College, *The Stevens Indicator*, December 1947.

[4] Hockema, Frank C., "A Study of Higher Education for Engineers," Studies in Engineering Education IV, Studies in Higher Education LIX, the Division of Educational Reference, Purdue University, Lafayette, Indiana, June 1947.

Means

With ever-mounting operating costs, recent record enrollments, shortages of qualified teaching, administrative and counseling personnel and with building costs at record levels, administrative officers have been beset with hardly surmountable problems on every side. Valuable indeed to any institution are those teachers and those administrators who can meet the day's problems successfully without losing regard for the individual student. These teachers and administrators have had to rely often on carefully planned group techniques which provided both organized and informal individual contacts as needed. Close supervision of relatively inexperienced personnel has of course been essential.

Yet the potentialities of present engineering organizations and institutions have not been fully realized. Much can be done in communities near which local sections of the professional societies exist. Engineers in each local section who are sincerely interested in encouraging qualified young men to enter the profession can do much effective work in their community high schools through the aid of local school officials, the administrative officers of nearby engineering colleges and of the ECPD and ASEE Committees on Student Selection and Guidance. Inspection trips for interested high school students to the local utilities and industries would stimulate the imagination of many young men who have absolutely no concept of their daily dependence on engineering for obtaining water, gas, electricity, telephone, radio, newspapers, the various modes of transportation, and the conveniences of modern life. The creative, cost-conscious role of the engineer could be painted in hundreds of instances. Our engineering colleges would, in many instances, benefit greatly by having students who had a far sounder concept of their prospective roles in American Society.

A student's high school record in the physical sciences, in mathematics, in English and in student leadership can provide a good clue as to his potentiality for the study of engineering. Better still, consideration not only of the high school record but of test scores on the Pre-Engineering Inventory, the College Entrance Examination Board Tests or of test results of the better fee-charging individual guidance organizations can provide an excellent basis for judging potentialities of prospective engineering students. Careful attention to the individual's stated objectives in seeking to enter engineering college, of tested or demonstrated proficiency in important preparatory work, and of personal qualities as disclosed by interview with the admissions officer or his representative can raise the caliber of entering classes.

Adequate counseling of students, individually as well as in groups, by friendly, interested, able and well-informed staff members has no substitute. These student contacts can probably be most effective where the counselors are of professorial or deanship rank. Staff members of this caliber are likely to be respected by students and can often do much in a short time to cause each student to give careful analysis and mature consideration to his problems. As compared with graduate student assistants, the abler, more-experienced staff members can generally counsel students more satisfactorily in less time and cover a greater variety of counseling problems. Often they are also better able to serve as administrative listening posts regarding matters of importance to students. An effective compromise is sometimes possible by having bright, young teachers who have shown a real understanding of their students to serve as counselors for one or two years under the close direction of a student dean or of a department head. The broadened training of these young men cannot help but prove of value to them and to their institution whether they remain in counseling or turn to administrative or teaching duties. The assistance of psychologically-trained personnel full-time or on a referral basis for vocational advisement or for the

handling of maladjusted students, has proved its worth in a number of institutions.

In and out of the classroom, the well-balanced, well-trained, friendly engineering teacher who likes his students and who likes to teach can perhaps do more than anyone else to individualize engineering education. Even the ablest, most zealous teaching staff can at times fail by far in accomplishing its best because of large classes, a heavy teaching load, lack of time for professional study and thought or any of several poor teaching conditions. Despite the pressures of large enrollments, limited finances and limited facilities, administrators who are interested in the individual student will always strive to create the most favorable teaching conditions possible.

The good teacher will always "spark" his students to begin their self-education and will, by example as well as direct instruction, strive to develop in them a professional spirit and a high regard for professional ethics. Much remains to be done among some of our teachers who either have little interest in, knowledge of, or understanding of the basic creeds of the engineer as set forth in the ECPD, Faith of the Engineer and in the Canons of Ethics for Engineers. Not until all of our teachers wholeheartedly accept, believe in and practise the ideals and standards of professional conduct set forth in these documents can we hope for widespread acceptance of them by our graduates. Each engineering college can go a long way toward developing on the part of its graduates a real sense of pride in their profession by encouraging them to take the engineer-in-training examinations, if any, in their state, as an essential first step towards personal recognition as an engineer.

As a final step in individualizing engineering education faculty members through an efficient placement service can not only make careful personnel recommendations regarding the significant attributes of their students for employment, but advise with them regarding the relative advantages of different employment possibilities.

In short engineering education can be individualized by: (1) creating inspirational contact between young high school men and practising engineers, (2) selecting for our colleges applicants of greatest real promise, (3) helping them individually to develop the skills and knowledge basic not only to engineering but to a full personal life as well, (4) helping them to mature a personal philosophy consonant with the highest professional standards and the needs of free people everywhere, (5) helping them through beginning licensing provisions toward a legal professional status and (6) helping them to obtain employment likely to lead to their fullest professional development.

College Notes

The 1950 Heat Transfer and Fluid Mechanics Institute will be held on June 28, 29 and 30, in Los Angeles at the **Institute of Aeronautical Sciences Building.** The sponsors will include the California Institute of Technology, Santa Clara University, Stanford University, University of California, University of Southern California, as well as a number of engineering societies.

Papers of a high technical level will include: Nonisothermal Turbulent Flow with Variable Fluid Properties; Regenerative Hear Exchangers; Statistical Analysis of Turbulent Flow; Combustion Stability; Diffraction of Shock Waves in Transient Flow; Nonsteady Flow; Multiphase Flow; and other topics.

Opportunities for Engineers in the Field of Nuclear Engineering*

By L. B. BORST

Chairman, Reactor Science and Engineering Department, Brookhaven National Laboratory, Upton, Long Island, N. Y.

"Go west, young man, go west" was the famous injunction of a famous editor of the past century. At the midpoint of the twentieth century we no longer have a geographical frontier. The question for us to analyze is whether the twentieth century frontier lies in technical directions and, for the present discussion, particularly whether Atomic Energy constitutes a segment of this frontier.

Let us examine the nature and extent of the present atomic industry. The Congressional appropriation for the present fiscal year is $750 million. These funds are used by the United States Atomic Energy Commission. In addition the armed services are allocating significant funds to specific atomic energy problems.

In this field labor constitutes the principle cost as the number of persons employed directly or indirectly is about 200,000. Because of the diverse varieties of skills represented it is difficult to estimate accurately the number of technical personnel. The highly technical nature of the total effort certainly involves an unusually high ratio of scientific and engineering talent. It is probable that more than one in every fifty persons deriving employment from the Atomic Energy Commission has scientific or engineering training. Considering equal numbers of engineers and scientists we therefore derive a total engineering personnel of 2000 employed on Atomic Energy Commission funds at the present time. Under present conditions this is certainly a low estimate since construction comprises a large fraction of Commission activities for the present year. If 30 years is assumed as the average technical life of an engineer, then the long term rate of replacement will be 70 per year.

At the present time the number of employed per year is much larger, due to the building up of various programs. While there is a real and urgent need for men trained in this field, there is no adequate existing source of such engineers. It is apparent from the foregoing that nuclear engineering has the potentialities of a stable market which, while not large in comparison with many consumer goods industries, is nevertheless significant.

What is nuclear engineering? Perhaps it is as diversified as all the various specialities of engineering. Let us examine the various existing installations for insight into its many ramifications.

Existing Installations

First there is the Los Alamos Scientific Laboratories which are devoted to the production and improvement of weapons. Meticulous chemical processes prepare the materials which are costly and deadly. Precision parts are fabricated by novel means. Experiments are conducted which require a highly coordinated organization, and in which great care must be exercised. In all this work the possibil-

* Presented at the Fall Meeting of the E.C.A.C., Kansas City, Missouri, October 28, 1949.

ity of accidents must be minimized, and the protection of personnel must always be the first consideration.

The Armed Services whose responsibility it is to develop means of delivering the weapon, and who must understand its properties and uses, have work in progress to these ends.

The General Electric Company operates the plutonium production plant at Richland, Washington. This is a process industry in which the operating and maintenance engineer and the production man will find most scope. The production of the plutonium in a reactor while involving a nuclear transformation, usually thought to be a subtle process of nuclear physics, has the atmosphere of a water treatment plant, or an oil refinery. Chemical separation and purification of the plutonium, carried out by remote control, is an exceedingly elaborate and tricky operation requiring ingenuity on the part of the operating staff.

At Oak Ridge the Carbide and Carbon Chemical Corporation (so named because it had no connection with any of these things, i.e., carbon, carbide or chemistry) operates the gaseous diffusion plant. This is perhaps the largest and most complicated continuous flow project in history. Here again the cost minded operating or maintenance engineer is in his glory.

The Argonne National Laboratories and the Oak Ridge National Laboratories do not have routine production commitments beyond the preparation of exotic and unusual isotopes for use in research and medicine. Their other functions are development and research. The Atomic Energy Commission has centered reactor development at Argonne. An extensive design and development organization is forming which will have as much as it can handle to design and execute the various reactors presently planned. There is ample opportunity here for the design engineer, and for the man with novel ideas.

The Knolls Atomic Power Laboratory of the General Electric Company (under the able direction of Dr. Kingdon) as its name implies is responsible for the development of future power reactors. Here again there is opportunity for men of many specialties who have imagination.

Brookhaven National Laboratory is dedicated primarily to fundamental research upon which may be built future technology. While most of the Laboratory is devoted to the usual scientific disciplines—physics, chemistry, biology and medicine, the group now supervising the construction and initial operation of the reactor wll devote its time in the future to the study of some of the more fundamental obstacles confronting the reactor field.

Both at Brookhaven and at Berkeley, California, billion volt accelerators are under construction. It is in this direction that most scientists expect revolutionary nuclear discoveries to lie. Yet even in these pioneering ventures the mechanical, and much of the electrical, design is in the hands of engineers.

Servicing Organizations

The foregoing discussion has been devoted to the Atomic Energy Commission installations. Other smaller organizations abound, devoted to various specialized objectives in which engineering plays a greater or lesser role. Certain parts of the over-all program are carried out within the sphere of private enterprise with little or no government supervision.

The mining of uranium and the concentration of the ore are carried out in as free a fashion as the law will permit. Colorado is the principle site of uranium mining, though I presume prospecting is carried out in every state of the Union. The mining engineer can perhaps find his place in the over-all program with less adjustment than any other engineering specialist.

There is a great need for the development of reasonably economical methods for concentrating low grade ores, found

in abundance in many states. Such investigations could be conducted in university laboratories just as well as in Commission installations.

A large variety of industries participate in the general Atomic Energy Commission program to a greater or lesser degree. The uranium is purified and prepared in usable form in a long sequence of industrial operations. While materials control and ascending degrees of security must be applied, the general framework is industrial in the normal sense.

Special materials are required in different phases of the development. Beryllium is often considered for use as a moderator in a reactor. The availability of beryllium in the requisite amount and purity is sometimes a limiting factor for the design engineer. Up to the present time we have found no magic structural metal or alloy which has a reasonable strength at elevated temperatures, resists corrosion under operating conditions, and yet has a low neutron capture cross section. Several rare and exotic metals are being prepared and tested, and from these the future design engineer must choose. Several university and industrial laboratories are participating in this work.

Gadgets and mechanical or electrical devices are required of an almost unending variety: special valves, pumps with no moving parts, unusual welding machines, filters, automatons by the dozens, to name a few. In most cases members of the Atomic Energy Commission endeavor to develop industrial sources for such components if they can be found or stimulated.

Radiation detection instruments are sufficiently important to be treated separately. In all nuclear work instrumentation is of paramount importance. Since radiation gives no stimulus to any of the senses, instruments must take their place. The inventory of specialized instruments at an atomic laboratory is truly impressive. Radiation instruments have been declassified as a field, by the Atomic Energy Commission, in order to stimulate commercial development. Here is a real opportunity for inventive genius. Even now, though we use them by the thousands, we have no truly satisfactory personnel monitoring instruments.

As important perhaps as all the foregoing enumeration is the last field. It is the most diversified and most promising, as well as the least developed. It is the often talked of "atomic age"—the application of our knowledge of nuclear phenomena to medicine and particularly to industry. At the present time a very few industrial applications are developing; for instance, a thickness gauge for measuring thin films. Similar to it is a liquid level indicator which consists merely of an instrument held near the exterior of the vessel.

The use of isotopes for research has often been discussed and, without question, has the most profound implications. The use of isotopes for analysis, process control and other normal industrial purposes has been slow in developing primarily because of a lack of trained persons able to see nuclear solutions to industrial problems.

Significance of "Atomic Age"

I have absolute faith that the much talked of "atomic age" will come, and that the nucleus will find an important place in American industry. How rapidly this will occur will depend largely upon how rapidly trained personnel get into the field of industrial applications.

Historically the atomic energy field originated in academic laboratories. During the war great national laboratories were established which were directed and supervised primarily by the trained scientists. Industries were brought in to work with the scientists to develop, construct and operate production plants. At the end of the war most of the scientists returned to their pre-war fields. While it has always been assumed that the

nuclear field would rapidly be turned over to industrial management, this transition has not been by any means complete. There has been a gap yet unfilled between the scientist/engineer teams of the war, and the long term industrial organization. The difficulty is that the really good scientists have returned to their pioneering, leaving the field to their less skilled brothers and to engineers with inadequate scientific background. The more rapidly the engineering profession can overcome its weaknesses, the more rapidly the field can advance.

The engineering student may properly ask, "This is all very well but is there a stable future in this field?" My answer would be that there is no more stable field in America. The present effort is guaranteed by the present international situation. Increased international tension will certainly bring increased effort. If international tensions relax, then several new possibilities exist. If international control becomes a reality, the control agency will require technically trained personnel. Who knows, atomic energy might even be included in President Truman's point four—calling for the technical development of backward countries. With relaxed international tensions will certainly come relaxing of security, permitting increased industrial development of the field.

Security is an ever present cloud over the whole field. By security I mean, of course, the restriction of information, the checking of personnel by the F.B.I., the review of information before publication, etc. Security as we all know is a necessary corollary of the present international situation, and will respond to changes as they occur.

The national importance of adequate development of this field cannot be overstressed. If we are to compete favorably with other nations we must give our best, for nothing less will do. We have seen recently that competing nations cannot be ignored. In spite of all statements from Washington, progress has been unexpectedly rapid. We no longer can piously say that we are better than the rest of the world, and that we are safe for ten to twenty years. In this atomic race, as in looking-glass-land, we must run to stay where we are, and must run very hard to get ahead.

When we take an overall view of the field we see vast unsolved problems in every direction. Can we breed fissionable materials? Can we produce power to compete with coal? What will we do with the atomic ashes, from our furnaces, that stay "hot" for centuries? How can we keep from contaminating our planet? Can we build an atomic powered airplane?

Of course these questions have all been resolved in the Sunday supplement, and they constitute no problem to the comic strip artists. But there are some of us who must do these things, to whom they do not seem simple. In this field there is the challenge of unexplored technical lands. Just as the early American pioneers visualized better land beyond each barrier, we see great rewards beyond each obstacle.

The obstacles we see are not subject to incremental attack. We cannot simply improve efficiencies by raising temperatures or pressures. They are fundamental, and cannot be solved with the aid of engineering handbooks. The problems must be attacked from first principles. The solutions to be found are unorthodox by normal engineering criteria, and come from the technical innovator who has a broad fundamental background. We need technical pioneering.

It is unfortunately true that the person of great ability will probably not receive the same monetary reward he would receive in private enterprise. It is doubtful if great fortunes will be made in this field. Development up to the present time has been at the expense of the people, and Congress has justly decided that there shall be no exploitation. Of particular importance in this regard is the government ownership of patents.

We find here the anomaly of all government. We need the most able people in

the nation, for if the future is dark, national survival may be at stake, yet the restrictions inherent in the work—security and remuneration—tend to drive away the most capable, and the most needed persons.

Yes, in my opinion Nuclear Engineering constitutes one of our technical frontiers. It is a young, vigorous, aggressive field. Its future is certain. Atomic energy is a permanent and rapidly developing field. There are few limitations on the young man of ability for he can advance as rapidly as he is able. There is little stagnation of ideas. Any good idea will be pursued and exploited as rapidly as as is consistent with the over-all program.

College Notes

A new five-story "engineering community center" was dedicated March 6 at the **University of Tennessee** College of Engineering. The $994,000 building houses a whole community of engineering activities—including teaching, research, cooperative training, extension of instruction throughout the state, training of industrial-arts teachers, and professional-society activity. The building was dedicated as "Perkins Hall," in honor of the late Dr. Charles A. Perkins, member of the engineering-college faculty for 49 years.

* * * *

David F. Smith, Vice-President, and Director of Research, Johnson and Johnson Co., has been appointed head of the Department of Chemical Engineering at **Michigan State College**, effective April 16.

The 1950 Medal of Honor of the Institute of Radio Engineers has been awarded to Dean Frederick E. Terman of the **Stanford University** School of Engineering, and Vice President of the ASEE. The medal, top award for distinguished service in the radio industry, was presented to Dean Terman on March 8 in New York City as a feature of the IRE annual convention.

* * * *

The Department of Mechanical Engineering of the **University of Illinois** announced the dedication of the new Mechanical Engineering Building on Friday, May 12. Concurrently with the dedication exercises, a Midwestern Conference on Fluid Dynamics together with a meeting of the American Physical Society, Fluid Dynamics Division, will be held.

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Demonstration Models—Their Use and Construction*

By R. S. HARTENBERG

Associate Professor of Engineering Mechanics, Northwestern University

Demonstration models, as the term is used here, are devices showing the action of a principle or giving physical reality to a situation. Their action is, in the main, qualitative, and they are often very helpful in the teaching of the various facets of mechanics. Demonstration models will not take the place of a good istructor or text, but they can enliven and brighten a classroom discussion: they aid in making a good instructor better.

There is, on the part of some, a reluctance toward using models based on the feeling that worthwhile models are difficult to construct, require hard-to-get material and must be built by highly skilled mechanics. The purpose of this paper is to demonstrate that this need not be the case; idea- and material-sources, techniques and useful but inexpensive tools are presented to show that the greatest investment is in time and patience rather than in money.

In general, an off-hand demonstration or quickie does not permit taking numerical data to reinforce an argument. If numbers are wanted, more carefully constructed models are necessary to insure the success of what is now an experiment. The transition from the model showing the general idea to the refined or experiment-model is (1) time-consuming, (2) in many cases difficult, (3) may not reach the ultimate in action because of friction or damping, whence (4) any percentage increase in action may be purchased quite dearly. For example, a simple gyroscope may be bought for a quarter in a toy shop, and will demonstrate everything a gyro has. A really good gyro, as used in a gun-director or navigation instrument, may cost thousands of dollars; and the gyro free of precession has not yet been built. There are, of course, certain models which, even in their crude state, can't miss. Thus, a piece of dowel rod is bound to have its center of percussion at very nearly the right place.

Rules for Effective Use

Taking off numbers for the calculation of quantities slows the demonstration, and may even negate it in the sense that one is too long in coming to the punch line. The quickie, with sure-fire action, leaves its mark on the student when properly presented. The basic rules for effective use would seem to be the following:

1. Analyze the model in its relation to (a) the best time or place to use it. and (b) the best way.
2. Practice the demonstration until it can be done with aplomb.
3. Be sure that all the equipment is at hand and in working order. Too short an extension cord, a loose screw, do wonders in creating an embarrassing start.
4. Prepare the student; arouse his interest by telling him what to look for, and how it may be applied.

* Presented at "Educational Methods" session, June 21, 1949, Annual Meeting A.S.E.E., Troy, New York.

5. Demonstrate, pointing out any less obvious happenings or secondary effects.
6. Follow through by
   a. applying the pertinent theory, and showing the approximate verification afforded by the demonstration;
   b. explain the aberrations and/or secondary effects and discuss what shortcomings of the model caused them, and how troublesome it would be to rectify them;
   c. reshow the demonstration to be sure that everyone has seen what there is to be seen;
   d. apply the general notion to events of everyday familiarity, as the old car lurching around on loose shacklebolts, or the tricycle aircraft landing gear;
   e. ask for student comments on the device, and suggestions for similar and other devices.

Many of us have to contend with what materials and components we have available, can liberate, or can conveniently buy. Under these circumstances a detailed preliminary design, with everything calculated, is out of the question, for that would in most cases lead to absurd specifications or call for parts not readily available. If models move too fast, for example, then the observer will certainly lose the benefit of the demonstration—and how many of us are in a position to say offhand that 3 cycles per minute are ever so much better than 10? This is something that is best settled by an actual test or tryout of the model on a group of colleagues; when the speed, amplitude, or whatever it is, is judged satisfactory for the purpose, the model may be put into its ultimate form.

It is necessary to be practical about the use of stock sizes in such items as spring wire, drillrod sections, springs, pulleys, motors, and the like. The rationale in design is to proportion the model to the readily available material, rather than to call for odd sizes.

Prepared Models versus Impromptu Models

The model should be mechanically simple, so that mechanism does not overwhelm the showing of the principle or action. The model should be of pleasing appearance to carry out the philosophy of "If it's worth doing it at all, it's worth doing well." Demonstrations made on the spur of the moment from junk collected out of pockets (rubber bands, paper clips, pencils), or off the chalkrail (chalk, eraser, yardstick), or objects otherwise impressed into service (book, paper) are very fine: indeed, they may be among the most effective demonstrations because they show the student that principles may be observed or actions determined without formal models. But when there is a prepared model, either carried into a classroom or shown in a laboratory, then it should reflect the fact that loving care was used in the fabrication and finish as well as the design. With this in mind, the models shown † have been neatly finished to a uniform standard; e.g., where there is a mass whose motion or position is of importance, the mass is called out by finishing it in white, and red is used for a second mass if it is present.

Rather effective use may sometimes be made of laboratory specimens, either whole or broken, when they are taken into the lecture room, for then it is possible to save the labor of adequate sketches showing the situations presented by the specimens. In addition, the student gets a physical connection by handling and seeing at close range the sort of thing of which the lecturer is speaking.

Pictures from industry are very effective too, for they bring the reality of engineering to the student; he can see for himself that there are, in the wide world, applications of the sort of thing being discussed: previously abstract theory

† A number of models, and photographs of quite a few, were on display at Troy.

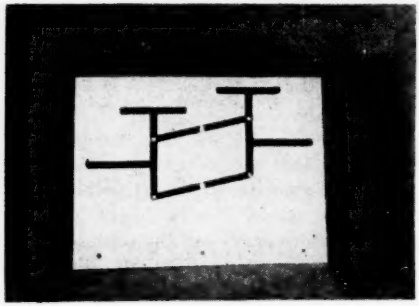
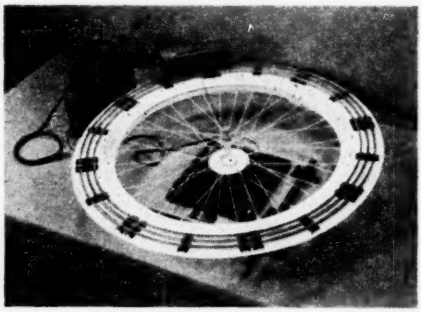


FIG. 1. Principle of virtual work. The Roberval Balance is constructed of fiberboard assembled with eyelets and supported by thumbtacks on a Masonite backboard.

takes on a new and real meaning when applied to a real machine or structure.

By the same token, a great deal of interest is created when the operation of certain toys is explained on the basis of the dynamic theory or theories involved. Two such toys are represented in the "Putt-Putt Boat" and the "Wirlwing"; there are others, like the little men who shuffle down inclines, and the animals that walk when they are pushed by means of a flexible steel handle.

Link mechanisms of considerable complexity can be quickly and easily constructed at one's desk without the aid of a machine shop. The links may be made from stiff paper such as the Accopress binders (available in different thicknesses), cut into width on a photo-trimmer if one is handy, and joined by means of a Bernard punch and eyeletter known as "Triumph" ($3.85). The eyelets may be squeezed gently for a swing fit, or set more firmly if the joint is to be fixed. Models made in this way are very satisfactory for most purposes. If a model is to be fabricated from metal, then more expensive materials are required, conventional shop equipment is needed, mistakes in judgment become costly, and much more time has to be spent on the actual construction. The fiberboard models, while perhaps not as accurate as their metal counterparts, may be very acceptable substitutes, particularly in showing the way a mechanism of many links works —how the various pins or link ends trace out the astonishing curves, or how the rods of a radial engine don't get tangled. Certainly in many cases they are superior to a drawing board layout if there are more than three connected links, for the graphical construction is not only tedious but confusing as well. To do even a fair job of layout work on the blackboard is at best a very time-consuming undertaking. As a quick means of experimenting with various combinations of links, this paper scheme is hard to beat. It also shows the student how in later life he might be able to approach a nasty linkage problem.



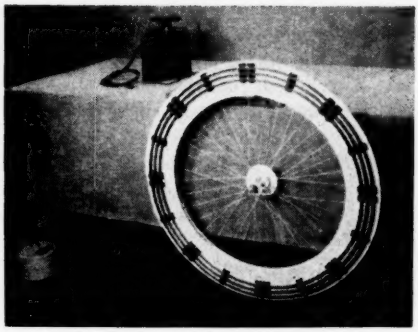


FIG. 2. Conservation of momentum. The bicycle wheel carries an 0–27 track circle. The wheel may be swung as a compound pendulum to determine its moment of inertia.

Drawing paper is convenient for some structural models; thus, cylinders of various diameters are cheap expendable models for illustrating buckling. Permanent models featuring various cross-sections and their moment-of-inertia properties can be made with a minimum of trouble and equipment.

Shop Techniques

I have found that things are done most efficiently if there is a degree of organization even when only one shop man is involved. Accordingly, I write "Job Orders" in duplicate instead of being content with verbal instructions. The artificer then has a written order of what he is to do, and with a backlog of orders, he can proceed on another job directly on finishing one. These Job Orders include the following:

1. Name of job.
2. Date of order.
3. Name of artificer.
4. Design sketches, with indication of major dimensions.
5. Indication of procurement of material, as
   a. on hand;
   b. office will order or pick up from model shop or hardware store;
   c. artificer is to pick up.

In general it has been my experience that the usual shop man, while very good for the heavy work in the Department, is not too well suited to the job of making models unless he has a background of instrument making: students who have built airplane, railroad, ship or car models, providing they can operate the necessary heavy machine tools, are most acceptable as artificers. Because of his background in physics and mechanics, the student has an understanding and appreciation of the goal the model is trying to reach, and he has a feeling for what modifications must be made in the cut-and-try process associated with the construction of models.

So far as possible, we use whatever material is handy or can be impressed for the job, and in order to have a stock of materials from which to draw, keep a large "hellbox" of odds and ends, and look through the box for additional ideas when the design sketches are roughed out.

FIG. 3. Magnus effect. The Wirlwing toy is essentially the S-rotor of Savonius, the wind providing the rotation necessary to produce the Magnus force.

For the bases we use birch or maple, finished with clear dope, rubbed down with 00 steelwool and waxed, giving a handsome but unobtrusive finish. The close grain of birch or maple makes it possible to drill and tap the wood, eliminating the need for metal fittings in many cases. In addition, the close grain accepts a black crackle finish very nicely to look like metal; it is certainly an advantage to be able to fashion supports, braces, and the like from wood with hand tools instead of having to use machine tools on metal.

Polished brass we avoid; it is nice to look at but difficult to keep in good appearance, and protective clear lacquer coatings peel with handling and age. A colored surface is easily cleaned with a damp rag or quickly renovated by a spray job.

Plastics we also avoid whenever possible, for they scratch easily, have a tendency to creep, and are difficult to join neatly, the usual cemented seam being rather unsightly due to an uneven glueline. Ordinary window glass may be used to represent planes; colored lines, arrows and other figures may be cut from colored "Mystik Tape," an adhesive fabric tape

available in a variety of colors and widths. This is in many cases a method preferable to masking and painting, or trying to paint lines of uniform width and density. Furthermore, errors of placement may be easily corrected by moving the tape instead of having to refinish the surface. The popularly used "Duco Household Cement" may be easily and cleanly removed from glass with a knife; errors on plastic cannot be corrected so simply.

For mockups and for mounting pictures the "Double-Coated Tissue Scotch Tape" is very convenient, for it provides two adhesive surfaces a very few thousandths of an inch apart.

In order to produce finishes having a professional look, we use a spray gun for the application of the finish. Since we are usually dealing with small surface areas, we find the "Dupli-Color" gun for $2.49 very convenient; small bottles containing the finish are screwed directly to the gun, eliminating the nuisance of cleaning containers when colors are switched. Our spray booth is merely a large box with some expanded-metal shelves; a small turntable fashioned from a roller skate wheel supports models to be sprayed on all sides. No exhaust system is needed since the workpieces are small.

We use airplane dope (lacquer), clear or colored, and black crackle finish, the choice of medium depending on the job. Thus, birch or maple bases are finished with a clear dope, metal parts such as supports are done in black crackle, and other model parts are finished in their proper color.

The use of dope has several advantages, among them being (1) quick drying, which means a speedup in the finishing operation, (2) an easily applied undercoat in terms of the "Primer-Surfacer" used by auto-body shops, (3) pleasing finish, (4) a choice of many colors, (5) availability in small containers, eliminating waste due to drying out, and (6) the fact that the overspray from lacquer dries to dust within a few inches of the gun, while paint or enamel overspray deposits even at a distance as a tenacious film.

Shops dealing in airplane, railroad or ship models should be investigated when there is need for small fittings, wheels, gears, paints and lacquers of various colors, and the like. For example, the railroad stores have available quite a variety of small structural shapes in wood, brass and aluminum. Other hobby shops may occasionally be able to contribute items difficult to make, or small, special purpose tools like leather punches, rivet sets, and carving chisels.

The chore of lettering may be greatly eased by using decalcomanias (decals). They are easily applied, and are now available in most paint and many stationery stores, although sizes smaller than ½-inch will have to be bought in a model-railroad store.

College Notes

In response to numerous requests, **Colorado A. & M. College** is initiating a summer program of graduate work leading to an advanced degree in Irrigation Engineering. The first term is from June 19 to July 14, the second term is from July 17 to August 11. In addition to regular courses, a number of half-day seminars in some particular specialty related to irrigation engineering and led by an outstanding authority in that field will be conducted. Subjects for seminars will be selected from the following range of topics: Irrigation Water Law; Interstate Water Administration; Water Measurement; Removal of Sediment from Canals; Canal Seepage; U. S. Bureau of Reclamation Programs; Administration of State Water Laws; Irrigation District Organization, Operation and Management; Water Requirement for Irrigation Groundwater; Evaporation Losses.

Thermodynamics from the Macroscopic and Microscopic Viewpoints*

By JOSEPH H. KEENAN

Professor of Mechanical Engineering, Massachusetts Institute of Technology

Why does the question of the microscopic versus the macroscopic viewpoint arise in thermodynamics but not in fluid mechanics? Consider, for example, the field of gas dynamics or high speed fluid mechanics which has come lately into prominence. It is concerned primarily with perfect gases the behavior of which can be explained in terms of the behavior of an ensemble of molecules. In comparison, the vapors, liquids, and solids of thermodynamics are highly complex structures from the microscopic point of view. Nevertheless, the teachers of gas dynamics appear, in general, to ignore the existence of the molecule whereas the teachers of thermodynamics seem to be forever plagued with the question whether to be molecule-minded or not.

Several reasons might be found for this anomaly, but the principal one is probably historical in nature. The failure of the caloric theory in the early nineteenth century shook the ground under the feet of the scientist. Here was an indestructible fluid—caloric—which was finally found to be destroyed or created at will. Firm ground was sought upon which to rest future analyses. One area remained unshaken—namely, the Newtonian laws of motion. These coupled with an old idea that heat or temperature—no one was clear which—was in reality agitation or motion of the ultimate particles of matter brought forth the "mechanical theory of heat." More properly this should be called the dynamical explanation of the first law of thermodynamics.

Influence of Newtonian Mechanics

The idea that nothing is understood until it is explained in terms of Newtonian mechanics took root in this period and flourished until late in the nineteenth century. One need only propose to explain relativity in terms of Newtonian mechanics to demonstrate how false it is.

Rumford, in the year 1799 upon discovering that he could produce caloric without limit, concluded that it "cannot possibly be a material substance" and speculated that it might be "motion." An embryonic kinetic theory of gases can be traced from the Greek philosophers through Francis Bacon, Boyle, and Euler. It was Helmholtz, however, who in 1847 was stimulated by the work of Rumford and Joule to lay the foundations of modern kinetic theory and to show that it would account for certain phenomena in perfect gases. It related, for example, work and temperature effects—the temperature being the analog of the vis viva or kinetic energy of the molecules.

The waters of kinetic theory were muddied by Rankine in his theory of molecular vortices which was a more complicated way of arriving at results similar to those of Helmholtz.

Carnot may be credited with getting thermodynamics off to a good start. His "Reflections on the Motive Power of Heat" of 1824 was simple and direct in

* Presented before the Mechanical Engineering Division at the Fifty-Seventh Annual Meeting, Troy, N. Y., June 24, 1949.

its approach. It avoided all question of an explanation of heat and clearly distinguished between *flow* of heat or caloric and caloric *residing* in a body. Kelvin in 1851 pointed to this important contribution: "An obvious principle first introduced by Carnot is that mechanical effect cannot be said to have been derived from a purely thermal source unless initial and final states are identical."

Convertibility of Heat and Work

Previous to this, all discussions of interconvertibility of heat and work were floundering over the definition of heat. Heat was a mode of motion. The new principle had seemed to be that some motion inside of a body could be converted into work, and vice versa. Since no one knew how to measure the motion in the body the principle could only be employed through "interpretation" which always included highly subjective elements. Carnot introduced into these discussions the cycle, for which the change in the unmeasurable motion was zero.

It was Clausius who in 1850 resolved the dilemma of Carnot's principle which had seemed to be true and important despite the vulnerability of the axiom—the caloric theory—upon which Carnot's proof rested. Clausius accepted Carnot's principle as a new fundamental law not requiring proof. Unfortunately, he never seems to have taken an analogous position as regards the first law. Kelvin stated the first law quite clearly in 1850 in the following form:

> "When equal quantities of mechanical effect are produced by any means from purely thermal sources, or lost in purely thermal effects, equal quantities of heat are put out of existence or are generated."

He previously explains that a "purely thermal effect" can be attained *in a cycle only*, and he subsequently states that the heat and work effects are proportional. Taking the statement along with its auxiliary explanations we could rephrase it in the following form: In a cycle the net mechanical effect (work) is proportional to the net thermal effect (heat).

Kelvin went on to "demonstrate" this principle by reference to a dynamical study of a molecular model. It is quite clear that he was not attempting to *prove* his principle.

The clarity of Carnot and Kelvin with regard to the First Law was lost upon Clausius and Rankine, both of whom attempted to *derive* the first law from dynamical principles. If one studies Clausius' text, "Mechanical Theory of Heat" one finds that his dynamical study was limited to a "Mathematical Introduction" which had little generality. When he got down to general considerations of thermodynamics his dynamical thesis simply passed from view.

Doubtless our engineering heritage of the "explanation" of the first law in terms of dynamics stems principally from Clausius and Rankine. These two had in common the splitting up of the energy of thermodynamics into two parts—the vis viva or kinetic energy and the ergal or potential energy. That of Clausius, being more readily understood, was generally copied. Rankine's devious and difficult methods served to convince engineers of the nineteenth century that thermodynamics was, after all, beyond ordinary human understanding.

Dynamical Approach

Can the dynamical approach to thermodynamics serve any useful purpose in teaching? The concept of a moving ensemble of particles can be used to show that a relation exists between work flow into the system and the sum of the Newtonian quantities, kinetic energy, and potential energy. But to reach the point where the change in this sum is given by the heat added in the absence of work requires a great amount of arbitrariness in the explanation of heat and temperature. Moreover, it involves two subsequently useless quantities—namely, kinetic energy, and potential energy of the particles.

When all this is done, in the interest of explaining the simple concept of a prop-

erty, the student is left with confusion in his mind as he faces each problem. Should he start the solution from the principles of dynamics of particles or from something else? If he follows the instructor's suggestion and leans on the dynamics of particles he will be as hopelessly lost as if he had done the equivalent in a problem of fluid mechanics.

Does the dynamical picture help one to teach the second law? We learn from kinetic theory, for example, that the analog of entropy is probability. From the standpoint of teaching thermodynamics this is a particularly useless concept. Thermodynamics must deal with equilibrium states, at least periodically; but the probability concept has utility only if non-equilibrium states are in question.

The great danger in the dynamical approach is that we shall, in the minds of our students, cramp our subject in the directions in which it is most general—namely, as regards the nature of the substance to be considered. This would be as unwise as it would be to restrict kinetic theory and quantum mechanics to the equilibrium states which thermodynamics demands.

It has been pointed out by A. G. Worthing † that temperature is not always a function of the kinetic energy of molecules. Certainly it has not been proved that within any range of conditions these two things are unique functions of each other for all the generality of substances with which thermodynamics can deal.

However unfortunate the attempt to expound thermodynamics in terms of kinetic theory of gases, no one can doubt that each of these subjects illuminates the other. It would be best if all students of engineering would master both. But mastering both means mastering each, and that in turn means the acquisition of clear-cut definitions and principles for each science without qualitative or quantitative confusion between them.

Of all the confusions between the two, there is one which should be treated with the utmost ruthlessness. With apologies to Ogden Nash, one might plead

Let's sink into the deepest ocean
The phrase "heat is a mode of motion."

† "Temperature," Reinhold (1941), pp. 41–44.

Thermodynamics from the Macroscopic and Microscopic Viewpoints*

By JOSEPH KAYE

Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology

The question under consideration is essentially pedagogical in nature. Should the engineering student be taught thermodynamics via the macroscopic or the microscopic viewpoint or via both? There is no doubt that the student should learn both viewpoints but there is considerable doubt whether the undergraduate or even the graduate student has sufficient time available in his curriculum to learn properly both viewpoints. Hence the question should be limited to whether the undergraduate engineering student should be taught first one viewpoint to the exclusion of the other. There is much to be said for introducing this student to thermodynamics via the macroscopic approach to the exclusion of the microscopic approach. After he has mastered his subject from the macroscopic viewpoint then discussions of kinetic theories will aid him and provide him with some approximate pictures or explanations of the relations between properties of a macroscopic system. On the other hand, very little can be said for the plan of introducing the engineering student to thermodynamics by the microscopic approach because of the state of this approach and because the background material required to present this method with an exactness and validity available in the macroscopic approach is possessed by few engineering students and by few teachers.

* Presented before the Mechanical Engineering Division at the Fifty-Seventh Annual Meeting, Troy, N. Y., June 24, 1949.

Thermodynamics has been a quantitative science for over a century. The two basic principles of thermodynamics have not changed significantly during this period but the so-called "explanations" of these principles in terms of theories of structure of matter have been many and varied in nature during the last century. If one were to repeat today the extremely careful and accurate experiments of Joule of a century ago on the relationship between heat and work in a cyclic process the measurements would lead to the same result, namely, the First Law of thermodynamics—only the definitions of the terms, heat and work, would appear somewhat different from those used by Joule. On the other hand, the "explanations" of this law from the microscopic viewpoint have been strongly dependent on the many theories of the structure of matter propounded in the last century.

Utilitarian or Fundamental Viewpoint?

Several questions arise in any discussion of the macroscopic versus microscopic viewpoint in the exposition of thermodynamics. Which viewpoint is of greater utility to the student in his first exposure to thermodynamics? Which viewpoint gives the student greater confidence in the applications of thermodynamics to both new and old situations in his engineering work? Which viewpoint is likely to be grasped more quickly by the student? Which viewpoint requires for quantitative applications the smaller amount of prerequisite material and so can be intro-

duced earlier in the undergraduate curriculum? There are many reasons which indicate that the answer to each question is the macroscopic viewpoint. In addition, there is much evidence strengthening this belief based on experience in teaching both thermodynamics and kinetic theory to undergraduates.

What is the macroscopic viewpoint in the exposition of thermodynamics? A clear and lucid answer is given in a recent paper by Keenan and Shapiro.†

In brief, the macroscopic viewpoint begins with the concept of a system as any collection of matter and with the implication that its size is relatively large compared to molecular dimensions; the terms property, state, process, and cycle are defined next. Then, depending on the method to be used, one defines such terms as work, equality of temperature, heat, abiabatic wall, and introduces the First Law in terms of these definitions. Several different methods of logically presenting the First Law lead to the same concepts and quantities, so that the teacher can choose any method which appears easiest to transmit to the student. The Second Law is stated in terms of these same concepts and definitions. Finally, useful deductions from the Second Law are presented together with the concept of a reversible process.

What does the engineering student obtain from this phenomenological approach to thermodynamics? He acquires a clear and unambiguous set of definitions, a set of principles, and many corollaries which are derived in a logical fashion from the basic principles. He understands the arbitrary nature of these definitions and the distinction between them and the principles. He learns to use only quantities which are carefully defined and are capable of measurement in the laboratory. He acquires confidence in the application of these definitions and principles to common every-day processes in engineering and soon can tackle problems which he has never seen before. In short, the student obtains in two semesters, one on elements and the other on applications, a high degree of confidence in his mastery of the subject plus the knowledge that his set of tools—independent of any theory of the structure of matter—is one he will be able to employ in his professional career.

A careful exposition of the macroscopic viewpoint will also indicate to the student the regions or problems where its principles must be supplemented; such is the case of non-equilibrium states. The macroscopic method is, however, still useful even in this case since the same logical approach the student has acquired can be used in such fields as heat transfer and mass transfer.

Kinetic Theory Viewpoint

What is the microscopic viewpoint in the exposition of thermodynamics? For an elementary course probably most teachers would use the basic concepts of the kinetic theory of gases. For an advanced course where the students possess a greater mathematical background one would probably use the methods of statistical mechanics in conjunction with the latest quantum theory of matter. Both types of courses would start with a model consisting of a very large number of particles.

Consider first the exposition of kinetic theory of gases. There are many molecular models available and one can start with masses of infinitesimal size or with hard spheres or with soft spheres, etc. The dynamical laws of motion—the Newtonian Laws—are applied to individual particles and to pairs of particles, in terms of the concepts of mass, force, acceleration, kinetic energy, potential energy, and momentum. The proper objective of the analysis is to obtain the relations between properties of the macroscopic system made up of the very large number of particles; in most instances, especially for

† "History and Exposition of the Laws of Thermodynamics," by J. H. Keenan and A. H. Shapiro, Mechanical Engineering, pp. 915–921, November 1947.

equilibrium states, the final result does not contain any quantity relating to the individual particles. For example, it may be easily shown that the product of pressure and volume is two thirds the average kinetic energy of the collection of particles. But the average kinetic energy of a huge number of particles is a quantity which is not measurable directly so that one introduces in an unsatisfactory way the assumption that the average kinetic energy of the particles is proportional to a "temperature" of the macroscopic system.

This assumption is clearly one of the weakest members of the structure of kinetic theory. In order to relate the properties of a collection of particles to observable properties of the macroscopic system, one is forced to use concepts completely foreign to Newtonian mechanics, namely, heat, thermal equilibrium, temperature, etc. Can one measure the "temperature" of a single particle of this collection? Can one measure the "heat" transferred from one particle to another? It is obvious that clear definitions of heat and temperature based on mechanics of a particle are required before one can discuss the measurement of these quantities. The engineering student is confused by this curious amalgamation of concepts from both the microscopic and macroscopic points of view. Moreover, the final result seen by the student is that the pressure-volume product of a gas is proportional to the temperature. Indeed, the student may question seriously the need for using kinetic theory at all in this connection since he will see through the faulty logic used in obtaining this result. We could say the student has been given a crude picture which may help him understand qualitatively this empirical relation of macroscopic thermodynamics, but he does not acquire a great degree of confidence in applying this picture to other practical problems.

Place of Statistical Mechanics

Let us consider briefly the subject of statistical mechanics as an example of the microscopic viewpoint in thermodynamics. It is illuminating to recall what the great master of both thermodynamics and statistical mechanics, namely Willard Gibbs, said in this connection on page 165 of Volume II of his collected works: "If we wish to find in rational mechanics an *a priori* foundation for the principles of thermodynamics, we must seek mechanical definitions of temperature and entropy." Gibbs clearly recognized, therefore, the importance of adding to the Newtonian laws those concepts which are useful only on the macroscopic basis. Gibbs did not, however, offer his readers any clear cut mechanical definitions of temperature and entropy but rather introduced these quantities by comparison and by analogy with the results of macroscopic thermodynamics.

Paradoxically, with such clear and lucid statements by men like Gibbs, one finds extensive confusion on this subject in the ranks of present day writers on statistical mechanics. They are not content with using this subject where it is powerful and fruitful, namely, in the prediction of properties of systems, but we find they must create great confusion in the minds of students by using careless and ambiguous definitions of such terms as heat and by giving poor "explanations" of the principles of thermodynamics. Indeed, in one recent text † the authors claim as an objective of statistical mechanics the derivation of the First and Second Laws of thermodynamics. The "proof" is given as follows: "The First Law of thermodynamics is an immediate consequence of the laws of mechanics as soon as heat is identified with the kinetic and potential energy of the molecules and atoms composing matter." A similar ambiguous statement is given to "prove" that the Second Law is a consequence of the laws of mechanics. Similar examples are available in other textbooks.

As far as I am aware, clear and non-ambiguous definitions of such quantities

† Mayer & Mayer "Statistical Mechanics," John Wiley & Sons, p. 86 (1940).

as heat, temperature, entropy, etc., in terms of measurable mechanical quantities—mass, length, time—have never been given by any writer. It is, indeed, highly improbable that such definitions will ever be forthcoming in view of the results of the latest quantum theory of the structure of matter.

The structure of kinetic theory and of statistical mechanics begins with an arbitrary model—the collection of a large number of particles—and proceeds to develop relations between macroscopically observable quantities. Thus with the aid of the latest quantum theory and data on energy levels of atoms from spectroscopic measurements, one can calculate accurately the specific heats, enthalpies, entropies, etc., of gases over a wide range of temperature. Likewise one can calculate accurately, by means of the methods of kinetic theory given by Chapman and others, the viscosity and thermal conductivity of gases over a wide range of temperatures. These results are extremely useful to the engineering student but on the other hand, the exposition of the methods used would require a large amount of mathematical background. Similarly, one can use the methods of kinetic theory in processes dealing with non-equilibrium states, such as heat transfer, mass transfer, thermal diffusion, flight at extremely high altitudes, isotope separation, etc. Again it is evident that instruction in such methods would be severely limited to a few students who have had the proper mathematical training.

On the basis of the above discussion it is evident that a simple and logical structure is available at present for the exposition of thermodynamics from the macroscopic viewpoint. It provides the engineering student with an accurate set of principles and tools which he can apply directly in his professional work. Furthermore, it can be introduced to the student early in his curriculum without requiring a large amount of mathematical background. A similar logical structure is not to be found in the methods of kinetic theory but rather one uses a loose structure of definitions, analogies, and comparisons, even in the more advanced theories of statistical mechanics. In an undergraduate course, the student learns many qualitative pictures or explanations while the accurate explanation is usually not taught except in advanced graduate courses. Hence the teacher should consider seriously the first exposition of thermodynamics to the engineering student solely in terms of the macroscopic viewpoint.

In conclusion, let us hope that those who teach thermodynamics from either the macroscopic or microscopic view will remember the words of one of the founders of thermodynamics, Lord Kelvin: "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of *Science*, whatever the matter may be."

Candid Comments

COMMENTS ON "DIFFERENTIATING CHARACTERISTICS OF AN ENGINEERING CURRICULUM" *

I wish to comment on Dean Hollister's article, "Differentiating Characteristics of an Engineering Curriculum," in the January, 1950 issue of the JOURNAL. I regard it as of extreme importance to engineering education that this E.C.P.D. matter be fully understood by engineering faculties and administrators—both the proposal itself and the present status of the proposal.

As I understand it, this document is the *proposed* answer of the E.C.P.D. Committee on Engineering Schools to the following twofold problem.

(a) What characteristics distinguish engineering curricula from other curricula (and thus determine which among those submitted to E.C.P.D. should be *considered* for accreditation)?

(b) On what basis will curricula thus selected for consideration be accredited?

The first thing to note is that the statement is a proposal; *it has not been approved by the E.C.P.D. Council.* As the *Editor's Note* states, it was presented to the Council last October. But it was not acted upon. Now is the time for engineering schools to study it carefully and indicate their opinions to the E.C.P.D. Committee on Engineering Schools. Presumably the Council will consider it again at the annual meeting of E.C.P.D. next October.

What follows is the substance of a statement submitted to the Council last October when the matter was presented.

This problem, which the Committee and Council have struggled with ever since the Council was organized, I know from experience to be a tough one. And it is as fundamental in its bearing upon the future development of engineering education as it is tough. For it must not be overlooked that the dicta of E.C.P.D. have *tremendous* influence upon the evolution—possibly even upon the freezing—of engineering education. I have discussed this with my colleagues, and we strongly hold the opinion that the matter is so important that adequate time should be provided and every possible precaution should be taken to insure, first, that the policies are so fundamentally sound that they will stand up under the test of time and of application to widely varied engineering fields and circumstances; and second, that they will be accepted as valid by the leaders of all branches of engineering and engineering education. Like proposed constitutional amendments—for it is equally fundamental—it should be accorded a review period: submitted at one meeting, acted upon at the next. For there are probably others like ourselves who, while fully agreeing with the Committee's statement of the problem and with the importance of finding a solution, and with the general approach of examining the functional borders between engineering and other fields, yet have reservations regarding the adequacy of some of the premises and thus of the conclusions.

* S. C. Hollister, "Differentiating Characteristics of an Engineering Curriculum," JOURNAL OF ENGINEERING EDUCATION, January, 1950.

"Ability to Design" Criterion

Our primary reservations are in regard to the proposed adoption of *"ability to design"* as the distinguishing quality —the "significant and distinctive element"—that differentiates the function of an engineer from that of his professional cousin in adjoining fields; and therefore in regard to the adoption of "the *process of analysis* and *synthesis* essential to designing" as the sought-for *"differentiating characteristics contained in an engineering curriculum."*

There are four fundamental objections to this conclusion.

In the first place, "ability to design" is not, in our observation and experience, the only distinguishing characteristic of what we have understood to be the function of an engineer. It characterizes some, but certainly not all, of such functions. What about a load dispatcher on a larger power system? His job certainly requires scientific background and knowledge of operating characteristics of apparatus, but not necessarily of design. What about the sales engineer who studies his customer's problem competently and recommends and sells a particular form and size of air compressor? He too must have technical background and knowledge of operating conditions and of the operating characteristics of such apparatus, but not necessarily of its design. Dr. R. F. Mehl tells me that to accept the Committee's premise that ability to design is the distinguishing characteristic—"distinctive element"—of the function of an engineer is to throw out practically all of metallurgical engineering and most of the branches of engineering embraced by the A.I.M.E. What about consulting engineers? (I used to be one.) Many of them deal with problems which of course require the application of scientific knowledge, but which—if they are to be dealt with *as whole situations*, as indeed they must be—require study and knowledge of operating conditions and of operating characteristics of apparatus or systems, but not necessarily of design in the sense in which it is defined in the document; and also these operating conditions usually involve practical, mundane factors of man and beast that the consulting engineer (and other engineers) must deal with, *as an engineer.* I am thinking of such functions as the analysis of some electrical power system trouble. For instance, the trouble may be bad load distribution among frequency converter sets because the operator failed to find that, because of vibration, the mechanical phase adjustment had shifted from the proper setting; or repetitive flash-overs on a transmission line owing to roosting birds. The point is that the solution of such problems as these—i.e., "trouble shooting"—is an engineering function and is one among others toward which engineering education should be directed; and also one that does not necessarily require either a knowledge of design *per se*, or the ability to design. And there are of course still other engineering functions. We think of a spectrum of functions—research, development, design, application, manufacturing, operation, construction, service, sales—all of them involving engineering in a characteristic way.

The second objection relates to a logical difficulty. In the first three pages the document concludes that the engineer is characterized by his *ability to design*, and properly aims to define "design" broadly. Then at the top of page 4 the conclusion is changed; there is amplification of what characterizes the engineer so as to include not only the ability to design but also "construction," "operation," "forecast," etc. All of the foregoing enlarges the definition; but by that much it decreases the usefulness of the original concept of "ability to design" as the key to the solution of the Committee's problem. To say that to be an engineer one must do all these functions "with full cognizance of their design"—i.e., design of structures, machines, apparatus, etc. —is hardly accurate, if expert knowl-

edge of their design is meant; and if, instead, is meant knowledge of operating characteristics, and of the theory underlying them, as seems likely and proper, then "ability to design" ceases to be a competent criterion.

Then even a further departure follows. In the middle of page 4, where the criterion for *engineering function* is applied as a test for an *adequate curriculum*, one finds the requirement that the curriculum should "furnish technical background and should supply also the general training, for the *process of analysis and synthesis essential to designing.*" This broadens the scope almost without limit, because the *process* of analysis and synthesis essential to designing is, if I understand it (I used to be a designing engineer), the same as the process of analysis and synthesis essential to any other engineering function such as I have illustrated above, or, for that matter, to almost any other truly professional function. So there is objection to the proposal on logical grounds: it starts with "ability to design," and ends with a "process" that is not even peculiar to design.

Effect Upon Accreditation Emphasis

The third objection relates to the importance of E.C.P.D. dicta in giving direction to the evolution of engineering education. Even if the design criterion itself were acceptable, I believe the document in its present form would, if adopted, tend to demoralize engineering education by encouraging undue emphasis upon and multiplication of design courses to the commensurate exclusion of more fundamental ones. The result, in our opinion, would be not only a tendency of schools on their own part to adopt such measures, but even also of accrediting committees themselves, guided by such a directive, to place undue emphasis on design courses. We are of the opinion that there is probably too much emphasis already on design; that design courses that stress routines and rules, without straight thinking from fundamentals, are educationally bad; and that a flood of just that kind of courses might follow such an E.C.P.D. dictum.

The fourth objection relates to the fact that in its topics the report is so particularized as to seem to tie down education unduly. Flexibility is extraordinarily important, because unpredictable and drastic changes are so inherent in our times as to make experimentation and adaptation more important than ever before in the history of engineering education. For example, on page 5 the fifth "section" specifies "general educational background." At C.I.T. we have no liberal courses designed *primarily* to give "a general educational background"; and yet I think our Social Relations Program is as truly liberal and as truly and vitally a part of engineering education as any humanistic and social curriculum; and certainly, however it may be judged as to its value, it is an experiment that should be encouraged. I cite it merely to illustrate our point that especially in these times it is important for authoritative statements as to what engineering education is, which are made for the purpose of accrediting educational ventures, to be far more basic and flexible than those in this document.

In view of all the foregoing, we urge that the Council take no final action upon the matter until the profession, including engineering educators, have had opportunity to study and fully understand the proposal and the implications. And thus we recommend that if the document is submitted to the Council at its forthcoming meeting this month, it be done with the proviso that it not be acted upon until the next meeting in October 1950.

This provision, it seems, would not unduly handicap the work of the Committee on Engineering Schools, because meantime it would naturally be authorized, as in the past, to make recommendations regarding accrediting under its own interpretation of existing general directives approved by the Council.

As a positive recommendation, we would suggest that the Committee might explore the question whether in the "five sections" (p. 293 of JOURNAL) it has not already indicated a logical and competent basis for solving the problem. Of these five sections, (2) and (3) together seem to characterize engineering curricula, *and to characterize no others;* and thus might be used as a criterion for part (a) of the problem. Moreover, if the five sections (with possible modification) prove to be acceptable, the accrediting job—part (b) of the problem—would be to settle what relative weight of emphasis should be given to the several sections. In other words, the five sections would seem to hold promise of being a basis for solving the whole problem.

ROBERT E. DOHERTY
President,
Carnegie Institute of Technology

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Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Wednesday, March 1, 1950, at Northwestern University, Evanston, Illinois. Those present were: Thorndike Saville, *President,* H. H. Armsby, F. M. Dawson, B. J. Robertson, F. E. Terman, J. S. Thompson, A. B. Bronwell, and D. Daum.

Report of Secretary

1. *Income Tax Status.* The Secretary reported that he had corresponded with the Commissioner of Internal Revenue to determine whether or not the Society was required to file a non-profit income tax return. A federal law requires some non-profit corporations to file returns, even though they are not required to pay taxes. The Secretary will report on the outcome of this inquiry at the next Board meeting.

2. *American Council on Education.* The Secretary reported that he had attended a meeting of the American Council on Education held in Washington, D. C., on January 27 and 28, 1950. This meeting dealt with: (1) the proposed reorganization of the U. S. Office of Education, (2) academic freedom, and (3) new developments in adult education.

3. *ECPD.* The President and Secretary attended a meeting of the Executive Committee of the Engineers' Council for Professional Development held in New York, on February 1 and 2, 1950. These meetings dealt with projects carried on by the various ECPD committees. One of the most promising developments is the work of the Committee on Professional Training. This Committee has formulated a program for expanding the educational and training opportunities for young engineers in industry. Several industrial centers have been selected to try out the plan. Cooperation will be sought between industry and the colleges in these areas.

At the ECPD meeting, President Saville called attention to the fact that a recent published report of the ECPD included only the major curricula accredited by the ECPD. It did not include the options which are also accredited, hence the list is misleading to persons seeking information on educational offerings of engineering colleges. The ECPD voted to publish a new report which will include the options.

4. *Nomination of Officers.* The Secretary reported that, despite the publication of the nomination blank in two successive issues of the JOURNAL, very few nominations have been returned. It was suggested that the Secretary should send nomination blanks to the chairman of Divisions, Sections, and Committees.

5. *Teaching Manual.* An advance copy of the manual "Effective Teaching" was circulated among members of the Executive Board. The Board expressed its grateful appreciation to Dean Norris, Chairman of the Committee, Professor Morris, author of the manual, and members of the Teaching Manual Committee for the excellent work in the preparation of this manual. President Saville announced that he will send letters to deans of engineering colleges suggesting that they make copies of this manual available to their faculty members, particularly to younger faculty members who can benefit most by its use. The manual is available from McGraw-Hill Book Company at a cost of $.60 per copy.

6. *Speakers Manual.* The Secretary reported that the terms concerning pub-

lication of the manual "Speaking Can Be Easy for Engineers" have been arranged with the ECPD. The manual will probably be available for distribution about the first of April.

7. *Committee on Improvement of Teaching.* This steering committee has been functioning for almost a year. It is planned to enlarge the group at the Seattle meeting. Professor Teare has asked to be relieved of the chairmanship and Professor Grinter has been appointed in his place.

8. *Charge for Reprints.* It was suggested that the Society adopt a schedule of two price scales for reprints offered for sale. The Secretary will prepare such a schedule and submit it to members of the Executive Board for their approval.

9. *Membership.* The Secretary reported that the Membership Drive is progressing satisfactorily. To date, over 700 new members have been elected during the current fiscal year. It is anticipated that approximately 1000 new members will have been added during the current fiscal year.

10. Resignation of the Assistant Secretary, Mrs. Daum, was announced, and Secretary Bronwell announced that Miss Margaret Wiltberger has been employed as office secretary.

Report of the Treasurer

1. A statement of receipts and disbursements as of February 28, 1950, was discussed and approved by the Executive Board.

2. The Treasurer reported that a payment of the full amount had been received on an advertising account for which the advertising firm had become bankrupt.

3. The Executive Board voted to approve the request of the Committee on Engineering Economy for a budget allotment of $20.00 for the current fiscal year.

4. The Executive Board voted to authorize the payment of half of the expenses of a representative of the Educational Testing Service up to $150 to attend the Annual Meeting in Seattle, provided that other sources pay a like sum for this project. A conference will be scheduled to discuss future plans for the Measurement and Guidance Project.

5. Motion was passed to approve the revised budget for 1949–50 as prepared by the Secretary and Treasurer.

6. The tentative budget for 1950–51 was discussed. This budget will be considered further and acted upon at the June meeting.

Report of the President

1. *National Science Foundation Bill.* President Saville distributed copies of the bulletin prepared under the sponsorship of the EJC, outlining the purposes of the National Science Foundation Bill, and urging action in its behalf. President Saville indicated that an amendment requiring clearance from the State Dept. for all persons benefiting from this bill might delay its passage. The Executive Board expressed the opinion that such an amendment would be a deterrent to the program and was unnecessary for the purpose of the bill. It felt that a loyalty oath would be more expedient, less costly, and sufficient for the purpose.

2. *Medical Education Bill.* President Saville reported that a conference of Engineering Deans and sanitary engineers was held in connection with the Sanitary Engineering provisions in the Medical Education Bill. This conference prepared a petition to be sent to the House Rules Committee advocating the inclusion of sanitary engineering in the bill.

3. *Committee on Unity of the Engineering Profession.* President Saville reported on his activities as representative of the Society working on the Committee on Unity of the Engineering Profession. Several preliminary proposals have been submitted for an organization which could represent the entire engineering profession in matters relating to

government and professional developments. A compromise proposal has been drawn up and is now before the Committee. President Saville will report on this matter at the next Board meeting.

4. *Financing of Higher Education.* President Saville reported that he has had a conference with Dr. Millet, of Columbia University, Chairman of a Commission set up by the Carnegie Corporation and the Rockefeller Foundation to study the financing of higher education. Dr. Millet offered the following two alternatives to the Society with respect to exploring the costs of engineering education:

(1) The ASEE would undertake the entire responsibility of determining the costs of engineering education, with the Commission subsidizing the undertaking; or

(2) The Commission would solicit and tabulate the information relating to the costs of engineering education, but the Society would appoint a special advisory committee to collaborate with the Commission in the preparation of the forms and in interpreting the data. The Commission will pay the expenses of the Advisory Committee members to attend meetings.

The Executive Board favored the second plan and recommended that a carefully selected committee, consisting of administrators of engineering colleges who are thoroughly conversant with budgets of engineering colleges, should be appointed to serve in this capacity. President Saville will work with Dr. Millet on this proposal and will report further at the next meeting of the Executive Board.

5. *Atomic Energy Commission.* Messrs. Armsby and Saville, representing the Society, have had conferences with members of the Atomic Energy Commission in regard to the expansion of educational programs in the atomic energy field as related to engineering. A number of regional conferences for small groups of engineering professors which would include representatives from atomic energy plants was suggested as the best means of accomplishing this purpose. The Executive Board voted to request collaboration with the Atomic Energy Commission in the holding of such regional conferences on nuclear energy under the joint auspices of ASEE and AEC. A special committee of the Society will be appointed to implement this program if satisfactory arrangements can be made with the AEC.

6. *Professional Recognition.* The Executive Board has studied the Report of the Committee on Professional Recognition of the ECPD regarding uniformity of grades of membership in engineering societies. However, it voted to take no action, since the Society has only one grade of individual membership and hence the ECPD report does not apply.

Report of Vice President in Charge of Sections and Branches

Vice President Armsby presented his written report of activities, indicating that the manual for Section officers will be ready for submission to the Executive Board at its June meeting.

Vice President Armsby, as representative of the Society, attended a conference held by the U. S. Department of State in Washington, D. C., on February 2 and 3, 1950, on the Point IV program. The Executive Board requested that Mr. Armsby notify them as to any scheduled hearing dates so that someone may be appointed to represent the Society at such conferences.

Vice President Armsby reported that the Minnesota Branch of the Society had voted to make application to join the Minnesota Federation of Engineering Societies, subject to the approval of the Executive Board. The Executive Board authorized this affiliation provided that it does not involve the ASEE in any financial commitments, and pending determination by the General Council of a general policy on this question.

Report of Vice President in Charge of Divisions and Committees

Vice President Robertson presented an outline of some of the problems arising in connection with summer schools. He was authorized to form a committee to work on the problems presented in this outline, the committee to report to the Executive Board prior to the 1951 annual meeting. It was also suggested that this proposed committee confer with the Committee on Improvement of Teaching.

Vice President Robertson presented the request of the Humanistic-Social Studies Division to hold a summer school at the University of Washington, Seattle, Washington. The Executive Board voted to approve Society sponsorship of this summer school.

Vice President Robertson also presented the request of the North Midwest Section to hold a seminar dealing with teaching methods in May, 1950. The Executive Board voted approval of Society sponsorship.

Report of the ECRC

Vice President Dawson submitted a current financial statement for the ECRC. He asked permission of the Executive Board to draw upon the balance of the funds which were originally transferred to the ASEE by the Engineering College Research Association for this year's operations. The Executive Board voted approval and asked the Secretary to handle the accounting so that this would appear as a charge against an ECRC reserve account rather than as an expense of the ASEE.

Vice President Dawson reported that ECRC had completed publication of its proceedings and that the decision as to whether or not they should proceed to publish the new booklet similar to "The Payoff in Research" would depend upon the availability of funds in the ECRC account.

Report of ECAC

Vice President Terman reported that the Executive Committee of the ECAC would meet soon in New York City to complete plans for the year's activities and the conferences at the annual meeting in Seattle. All of the ECAC committees, with one exception, are planning conferences at the annual meeting.

Fall Meeting of ECRC, ECAC, and General Council

The Executive Board voted that the Society should hold its usual fall meetings of the ECRC, ECAC, and General Council in conjunction with the Land Grant College Association meeting, during the week of November 13–18, 1950, if this arrangement is satisfactory with the Land Grant College Association. Secretary Bronwell will contact the Land Grant College Association regarding suitable times and dates for the meetings.

Annual Meeting

1. *Registration fee.* Because of the large deficit incurred by the host institution during the 1949 annual meeting, the University of Washington has requested permission to charge a registration fee at the 1950 annual meeting. It was pointed out that increasing the price of meals to defray costs was a poor solution, since it discouraged attendance at the scheduled luncheons and dinners. The Executive Board voted to request the host institution to submit to the Secretary of the Society a budget showing their anticipated income and expense and also indicating the anticipated deficit. The President and Secretary of the Society are then authorized to set a registration fee to be charged by the Society, this fee not to exceed $3.00 per person, with no additional charge for other members of a family. The host institution will be reimbursed out of this fund for such items in the deficit as appear appropriate to the President and Secretary. Any amounts collected through this registration fee in excess of the expenditures authorized will be the property of the Society and will be set up in a reserve fund for future annual meetings.

2. *Conferences.* The Executive Board voted that all morning conferences at the annual meeting should commence at 9:30 A.M.

3. *Future Annual Meetings.* The Executive Board discussed the outstanding invitations from various institutions willing to act as hosts at an annual meeting of the Society. A formal invitation has been received from Dartmouth College for the 1952 annual meeting. This location would conform to the regional rotational plan previously adopted by the General Council. The Secretary was asked to investigate the facilities available at Dartmouth College and report back. The remaining outstanding invitations were tabled for future consideration.

Enrollment Statistics

The Executive Board voted approval of a publicity release "Engineers Needed" prepared by Vice President Armsby. It was the opinion of the Executive Board that in future publicity releases on manpower and enrollment statistics, it would be advisable to include the over-all enrollment figures for all schools offering B.S. degrees in engineering which are listed in the U. S. Office of Education Bulletin, but to include supplementary data on enrollments in ECPD accredited colleges.

Institutional Memberships

The application of the University of Massachusetts for active institutional membership was approved by the Executive Board.

The Executive Board voted to approve the application of Nova Scotia Technical College for affiliate institutional membership.

Division of Relations With Industry

E. C. Koerper, Chairman of the Relations with Industry Division, presented a proposal for publication of a brochure to be directed primarily to small industries intended to increase demand for engineering graduates. The brochure would point out to small industries that they can strengthen their organization and enhance the possibility of long range successful operations by hiring engineering graduates at this time when there is a ready supply of mature veterans who are completing their college education. It will also point out that the number of engineering graduates will decline sharply in the years to come and the best opportunities for selection will occur in 1950 and 1951. It will also describe briefly how industries may utilize the placement services of the engineering colleges in selecting their personnel. This brochure would be published by the Society as quickly as possible, in order to be available sometime in April. A limited number of copies would be distributed free to deans of engineering colleges. Additional copies can be purchased. It is intended that the engineering colleges will send these, together with their own covering letters, to industries in their geographical area. The Executive Board voted approval of publication of this manual and subsidization of the costs of publication.

Mr. Koerper also pointed out that the Relations with Industry Division was contemplating preparation of a small booklet for engineering seniors, with helpful information on how to conduct interviews, ethics of interviewing, responsibilities and obligations of the young engineer toward his employer, etc. The Executive Board favored preparation of such a booklet.

Committee on Teaching Aids

Professor Carl Muhlenbruch reported on the progress of the Teaching Aids Committee. Messrs. Justice and Beatty have accepted appointment as representatives of the Society to solicit funds for the furtherance of this important project. The Executive Board voted approval of a budget allotment for the Committee on Teaching Aids in the amount of $100.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

THE T-SQUARE PAGE

Officers
O. W. Potter, *Chairman*
C. H. Springer
T. T. Aakhus
C. J. Vierck
R. T. Northrup
R. P. Hoelscher

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

W. J. LUZADDER, *Editor*
Purdue University

Officers
I. L. Hill
R. S. Paffenbarger
J. G. McGuire
W. E. Street
C. E. Rowe
H. C. Spencer

The Need for More Extensive Training in Engineering Drawing

The general trend in most engineering schools during recent years has been to reduce the time devoted to the teaching of engineering drawing. The time gained is generally used in the teaching of specialized courses in the student's major field.

Those who realize the importance of engineering drawing as a basic engineering skill and are aware of the fact that well organized courses in the subject can develop the habit of creative thinking and some practical reasoning should do all in their power to convince the administrators and curriculum committees that engineering drawing is very necessary, since it is the language of the engineer and since a large number of the graduates of engineering schools get their start on the drawing board. The argument of many administrators is that they do not want to train students to be draftsmen, but to be engineers. They are of the opinion that if a graduate is too good a draftsman he will be kept on the drawing board and not be given a chance for advancement. I do not agree with this point of view. One of the requirements of a good draftsman is that he do neat and accurate work. Would not this same man be a better man to promote than one who did careless and inaccurate work? Also at this time we might ask the question of what we should do about the large number of students who do not complete their college courses. Does not engineering drawing offer them about the only chance they have to enter a field allied to engineering?

The trend to reduce the time allotted to courses in engineering drawing during the years has been nationwide. Is something wrong with those of us teaching drawing courses that we do not continue the fight as presented by Professor A. S. Levens in his excellent paper, "The Effect of the Tendency to Reduce Engineering Drawing Time," in the JOURNAL of January 1940? I would like to see the Drawing Division appoint a committee to continue the study of this problem and bring the statistics up to date.

The recent report by the Committee of Minimum Standards for Engineering Drawing Courses recommended "that the total time for basic courses in engineering drawing shall be equivalent to at least 4 semester credit-hours, each credit-hour to represent three clock hours of work divided between lecture, laboratory, and homework as the individual departments may see fit. This time is considered as a minimum for satisfactory presentation of a minimum list of essential topics and does not include other topics commonly covered in descriptive geometry."

Is it any wonder that at institutions where drawing courses are granted less than these recommended minimum hours we are asked by fellow faculty members teaching design courses whether we can not teach our students to turn out better drawings? Probably these same faculty members base their grades wholly on the design part of the problem and allow the student to submit a drawing that would not pass the inspection of a teacher of engineering drawing. The technique of executing a good drawing is something that is acquired by the student only by continual practice. If these faculty members who teach design courses of which part of the work is on the drawing board could be induced to assist in teaching a course in engineering drawing for a semester, I feel confident that they would realize our lack of time to cover the subject sufficiently in all its phases. In this way they might become our strongest supporters for more time.

PROFESSOR L. O. JOHNSON,
New York University

Program

FIFTY-EIGHTH ANNUAL MEETING

AMERICAN SOCIETY
FOR
ENGINEERING EDUCATION

University of Washington, June 19–23, 1950

SEATTLE, WASHINGTON

PRINCIPAL EVENTS

Monday, June 19

9:00 A.M. REGISTRATION. Lounge, Student Union Bldg. (27).*

10:00 A.M. MEETING OF EXECUTIVE BOARD, ASEE. Faculty Club (30).

2:00 P.M. CONFERENCES.

6:00 P.M. DINNER MEETING, GENERAL COUNCIL. Seattle Yacht Club.

DINNER MEETING, WIVES OF COUNCIL MEMBERS. Seattle Yacht Club.

Tuesday, June 20

9:30 A.M. E.C.R.C. GENERAL MEETING. For program details, see Tuesday conferences.

2:00 P.M. CONFERENCES.

6:30 P.M. SMORGASBORD DINNER—FOLLOWED BY GENERAL ENTERTAINMENT.

Wednesday, June 21

GENERAL SESSION

9:30 A.M. FIRST GENERAL SESSION. Auditorium, Meany Hall (22). H. H. Armsby, *Vice-President*, presiding.

1. Nomination and Election of Officers.
2. Reorganization of the Federal Government. Dr. Raymond B. Allen, President, University of Washington.
3. Report on Society Activities. A. B. Bronwell, Secretary.
4. Open Discussion of Society Activities.
5. Engineering Education in a Changing World. Dr. Thorndike Saville, President of the Society, Dean of Engineering, New York University.

2:00 P.M. SECOND GENERAL SESSION. Auditorium, Meany Hall (22). B. J. Robertson, *Vice-President*, presiding.

1. The Role of the Engineer in Community Affairs. M. L. Cooke, Consulting Engineer in Management; Chairman, President's Water Resources Policy Commission.
2. The Role of the Engineer in Government. S. B. Morris, General Manager and Chief Engineer, Dept. of Water and Power, City of Los Angeles.
3. The Role of the Engineer in International Affairs. Speaker to be announced.

6:00 P.M. DINNER MEETING, Old and New Members of EXECUTIVE BOARD. Meany Hotel.

INTERNATIONAL GUEST NIGHT. Dinner and Conference. Student Union Bldg. (27).

8:00 P.M. CONFERENCES.

Thursday, June 22

9:30 A.M. E.C.A.C. GENERAL MEETING. For program details see Thursday conferences.

2:00 P.M. CONFERENCES.

*** Number in parentheses indicates number on campus map which will be furnished at time of registration.**

7:00 P.M. ANNUAL DINNER. (Informal.) Edmundson Pavilion (76). Thorndike Saville, *President,* presiding.

1. Engineering an Improved Economy. W. W. Williams, President of Continental, Inc.; Chairman of the Committee on Economic Development.
2. Presentation of French Medal of Academy Palm.
3. Presentation of Lamme Medal.
4. Presentation of George Westinghouse Award.
5. Announcement of James H. McGraw, Sr., Technical Institute Award Recipient.
6. Resolution of Thanks to University of Washington.

Friday, June 23

9:30 A.M. CONFERENCES.

MEETING, *Old and New* Members of General Council. 329, Student Union Bldg. (27).

12:30 P.M. LUNCHEON, *Old and New* Division and Committee Chairmen. Student Union Bldg. (27).

2:00 P.M. ADJOURNMENT.

CONFERENCES

Monday, June 19

12:30 P.M. LUNCHEONS

English

Student Union Bldg. (27).*

F. Abbuhl, Rensselaer Polytechnic Institute, presiding.

No program—a "Get Acquainted" hour.

Mineral Engineering

Raitt Hall (6).

T. L. Joseph, University of Minnesota, presiding.

1. Business meeting and election of officers.

Sections and Branches Committee

Student Union Bldg. (27).

H. H. Armsby, U. S. Office of Education, *Vice-President,* ASEE, presiding.

Business Meeting.

Monday, June 19

2:00 P.M. CONFERENCES

Chemical Engineering

Room 140, Bagley Hall (33).

W. Moulton, University of Washington, presiding.

1. A Course in Mathematics for Chemical Engineers. W. M. Stone, Oregon State College.
2. History and Present Status of Chemical Engineering Accrediting Program. G. G. Brown, University of Michigan.
3. How Industry Can Aid in the Cost of Educating Its Future Employees. L. Berg, Montana State College.

Civil Engineering (Hydraulics and Sanitary Committee)

224 Guggenheim Hall (34).

H. M. Gifft, Cornell University, and W. L. Moore, University of Texas, presiding.

1. Supplemental Field Training of Sanitary Engineers for Public Health Work. E. S. Tinsdale, U. S. Public Health Service.

   Discussion:

   L. J. Murphy, University of Missouri.
   H. Ludwig, University of California.
2. The Importance of Dimensional Analysis in Fluid Mechanics Research. Hunter Rouse, State University of Iowa, and M. L. Albertsen, Colorado A. & M. College.
3. Committee Report.
4. The Use of Visual Aids in Teaching Hydraulics at the University of Washington. T. H. Campbell, University of Washington.

   Discussion:

   L. A. Clayton, Oregon State College.
   H. J. Miles, Texas A. & M. College.
5. Business Meeting and Election of Officers. W. M. Lansford, University of Illinois, presiding.

Electrical Engineering

322 Electrical Engineering Bldg. (46).

F. O. McMillan, Oregon State College, presiding.

Theme: Some Features of the New Electrical Engineering Laboratories of the University of Washington.

1. W. V. Eastman, University of Washington.
2. R. E. Lindblom, University of Washington.
3. L. B. Cochran, University of Washington.

*** Number in parentheses indicates number on campus map which will be furnished at time of registration.**

4. General discussion and inspection of building.

Engineering College Research Council (Committee on Relations with Non-Military Federal Research Agencies)

Room 56, Johnson Hall (32).

R. A. Morgen, University of Florida, presiding.

Theme: Federal Research in the Northwest.

1. Research by the Fish and Wild Life Service.
   a. Research Leading Toward Conservation of Fish and Wildlife in the Pacific Northwest. S. J. Hutchinson, Fish and Wild Life Service, Portland, Oregon.
   b. Engineering Research as it Relates to Fishery Biology in the Columbia River Basin. J. T. Barnaby, North Pacific Fishery Investigations, Seattle, Wash.
   c. Research in Hydraulics as Applied to Anadromous Fish Facilities at Bonneville Dam. H. B. Holmes, North Pacific Fishery Investigations, Seattle, Wash.
2. High Voltage Power Transmission in the Pacific Northwest. S. E. Schultz, Bonneville Power Administration, Portland, Oregon.
3. Research Activities of the Bureau of Mines in the Northwestern States. H. A. Doerner, U. S. Bureau of Mines, Albany, Oregon.
4. Lower Cost Canal Linings. D. W. Applegate, Bureau of Reclamation, Boise, Idaho.

Engineering Drawing

Room 409, Education Hall (16).
O. W. Potter, University of Minnesota, presiding.

1. A Course for the Training of Teachers of Engineering Drawing. H. R. Skamser, Michigan State College.
2. Coordinated Drawing and Engineering Problem Courses for Freshmen. H. Boehmer and C. E. Douglas, University of Washington.
3. The Use of the Principles of Engineering in the Organization and Operation of the Drawing Department. J. Rising, Purdue University.
4. Sound Film: Shape Description. J. Rising, Purdue University.

Open Discussion.

English

Room 329, Student Union Bldg. (27).
F. Abbuhl, Rensselaer Polytechnic Institute, presiding.

Theme: Life of the English Teacher in an Engineering College.

1. One Broad Way Instead of a Blind Alley. G. J. Christensen, Lehigh University.
2. The Problem of Achieving Professional Recognition. A. C. Ames, Illinois Institute of Technology.
3. Rewards of Achievement. J. E. Thornton, University of Michigan.
4. Today's Need for Broader Training. A. V. Hall, University of Washington.

Open Discussion.

Mechanical Engineering (Heat Power Subcommittee)

Room 317, Guggenheim Hall (34).
N. A. Parker, University of Illinois, presiding.

Theme: A Panel Discussion on Instrumentation and its Instruction. S. Konzo, University of Illinois, Panel Moderator.

1. Should the Backbone of Laboratory Work be Fundamental Studies of Pressure, Temperature, Velocity, Time, etc.? C. F. Kayan, Columbia University.
2. Just What Are We Trying to Teach in Laboratory? F. L. Schwartz, University of Michigan.
3. Instruction in Instrumentation. H. L. Mason, Iowa State College.
4. Formal Experiments or Informal Education? E. F. Obert, Northwestern University.
5. Election of Heat Power Subcommittee officers.

Mineral Engineering (Metallurgical Section)

Room 211, Roberts Hall (48).
E. A. Rowe, University of Washington, presiding.

1. The Place of Metallurgy in Non-metallurgical Engineering Curriculum. L. W. Gleekman, University of Delaware.
2. Engineering Metallurgy Courses for Non-metallurgical Engineers. O. G. Paasche, Oregon State College.
3. Instruction in Metallurgical Calculations. Allison Butts, Lehigh University.
4. Canadian Views on Metallurgical Curriculum. E. A. Forward, University of British Columbia.
5. Metallurgical Education at the University of California. Ralph Hutgren, University of California.

Nominating Committee

Room 221, Student Union Bldg. (27).
H. O. Croft, University of Missouri, presiding.
(Open only to retiring members of General Council.)

Physics (joint with AAPT)

Room 231, Student Union Bldg. (27).
G. P. Brewington, Lawrence Institute of Technology, presiding.

1. Accelerators of Nuclear Particles. J. S. Streib, University of Washington.
2. Ramjets and Turbojets. J. E. Dwinnell, University of Washington.
3. Some Uses of the Electron Microscope in Engineering. Oliver Row, University of Washington.
4. An Analysis of Laboratory Instruction in Physics. Smith Cowell, South Dakota School of Mines.
5. Business meeting of Physics Division (4:00 P.M.) and election of officers.

Technical Institutes

Room 309, Anderson Hall (50).
C. T. Reid, Cal-Aero Technical Institute, presiding.
Theme: Recognition and Accreditation of Technical Institutes.

1. Opening Remarks. H. P. Adams, Oklahoma A. & M.
2. ECPD Technical Institute Accreditation. K. L. Holderman, Pennsylvania State College.
3. Government Directory Listing of Technical Institutes. H. H. Armsby, U. S. Office of Education.
4. Civil Service Rating of Technical Institute Graduates. H. A. Sawchuck, Federal Civil Service Commission.
5. Technical Institute Program "Experience" Credit Allowance by State Licensing Boards. L. M. K. Boelter, University of California.
6. Membership of Technical Institute Graduates in Professional Engineering Societies. E. W. Rentz, Jr., Society of Automotive Engineers.

Open Discussion.

Monday, June 19

6:00 P.M. DINNERS

Civil Engineering

Raitt Hall (6).
W. M. Lansford, University of Illinois, presiding.

1. Signs of Our Times. H. E. Wessman, University of Washington.

General Council. (Open to Council members only.)

Seattle Yacht Club.
Thorndike Saville, *President of ASEE*, presiding.
Dinner and Business Meeting.

Monday, June 19

8:00 P.M. CONFERENCES

Civil Engineering (Soil Mechanics Committee)

Room 224, Guggenheim Hall (34).
H. E. Davis, University of California, presiding.
Open session of the Soil Mechanics Committee to determine future policy and activities.

Engineering College Research Council (Committee on Relations with Industrial Research Agencies).

Room 329, Student Union Bldg. (27).
Dr. H. K. Work, New York University, presiding.
Theme: Industrial Research in the Pacific Northwest.

1. Industrial Trends and Their Influence on Industrial Research in the Pacific Northwest. Don Walters, Inland Empire Research Council.
2. Relation of Industrial Research to University Research. H. K. Benson, Laucks Company.
3. Some Major Fields of Industrial Research in the Northwest:
   a. Pulp. W. W. Moyer, Crown Zellerbach Corp.
   b. Chemicals. Don Redfern, American-Marietta Corp.

General Council. (Open to Council members only.)

Seattle Yacht Club.
Thorndike Saville, *President of ASEE*, New York University, presiding.
Business Meeting.

Mineral Engineering (Mining Section)

Room 211, Roberts Hall (48).
Milnor Roberts, University of Washington, presiding.

1. Development of a Ceramic Engineering Curriculum. P. D. Johnson, University of Washington.
2. A Curriculum for Present Requirements in Petroleum Engineering. H. H. Power, University of Texas.

3. A Summary of Industry's Views on Mining Curricula. F. A. Thomson, Montana School of Mines.
4. Training Prospectors in Extension Classes at the University of Washington. D. A. Pifer, University of Washington.

Tuesday, June 20

9:30 A.M. CONFERENCES

Engineering College Research Council
(General Meeting)
Auditorium (Division of Health Sciences) (63).
F. M. Dawson, *Vice-President of ASEE*, State University of Iowa, presiding.
1. Research in Western Canada. S. E. Maddigan, British Columbia Research Council, University of British Columbia.
2. Aeronautical Research—the Manufacturer's Viewpoint. D. W. Finlay, Boeing Airplane Company, Seattle, Wash.
3. Contamination from Atomic Bursts and Atomic Energy Plants. L. E. Donaldson, University of Washington.

Engineering Economy
Room 224, Guggenheim Hall (34).
W. D. McIlvaine, Jr., University of Alabama, presiding.
1. Engineering Economy, What It Is, and Its Place in Engineering Curricula. H. G. Thuesen, Oklahoma A. & M. College.
2. The Term Report as a Teaching Device in Engineering Economy. L. F. Bell, Stanford University.
3. Economics of Columbia River Development.
   1. S. B. Green, U. S. Army Engineers, Seattle District.
   2. M. E. Sutton, R. W. Beck and Associates, Seattle, Wash.

Discussion: Baldwin Woods, University of California.

Engineering Drawing
Room 409, Education Hall (16).
O. W. Potter, University of Minnesota, presiding.
1. Lighting in the Drafting Room. W. E. Potter, General Electric Company, Portland.
2. Functional Layout and Design in Aircraft. C. Chaffins, Boeing Aircraft Company, Seattle.
3. Manufacture of German Drawing Instruments. F. Oppenheimer, Gramercy Import Company, New York City.

Open Discussion.

Engineering School Libraries
Room 221, Student Union Bldg. (27).
Johanna E. Allerding, University of California, presiding.
Theme: Integration of Library Services with Teaching and Research.
General Discussion.

English
Room 329, Student Union Bldg. (27).
F. Abbuhl, Rensselaer Polytechnic Institute, presiding.
Theme: Literature in Technical Schools.
1. Teaching Literature to Engineers. W. Huse, California Institute of Technology.
2. Teaching Up to Engineers. C. Harold Gray, Rensselaer Polytechnic Institute.
3. American Literature for Engineers. Paul Fatout, Purdue University.
4. An Elective Course in the Novel. W. K. Brown, Rensselaer Polytechnic Institute.
5. Teaching Literature Through Dramatic Readings. J. Rustad, University of Washington.

General Discussion.

Mathematics
Room 322, Electrical Engineering Bldg. (46).
C. R. Wylie, Jr., University of Utah, presiding.
1. Some New Nomograms of Engineering Interest. C. R. Wylie, Jr., University of Utah.
2. The Teaching of Advanced Mathematics to Electrical Engineers. Cecilie Froehlich, City College of New York.
3. Instruction in Engineering Mathematics at the University of Washington. R. Q. Brown, University of Washington.
4. Election of Officers.

Technical Institutes
Room 317, Guggenheim Hall (34).
M. R. Graney, Purdue University, presiding.
Theme: Curriculum Studies.
1. Engineering in Less Than Four Years. N. C. Beck, Parks Air College.
2. Quantitative Analysis of Accredited Technical Institute Curricula. K. O. Werwath, Milwaukee School of Engineering.

Business Meeting. H. P. Adams, Oklahoma A. & M., presiding.

Tuesday, June 20

12:30 P.M. LUNCHEONS

Aeronautical Engineering, (Joint with **Engineering Economy** and **Industrial Engineering**)

Program details given under **Engineering Economy.**

Chemical Engineering

Wilsonian Hotel.

W. Moulton, University of Washington, presiding.

Election of Officers.

Committee Reports.

Electrical Engineering (Joint with **Relations with Industry**)

Student Union Bldg. (27).

E. M. Strong, Cornell University, presiding.

1. Engineering Education and the Requirements of Industry. Harold Osborne, American Telephone and Telegraph.
2. Business Meeting.

Engineering Economy (Joint with **Aeronautical Engineering** and **Industrial Engineering**)

Meany Hotel.

W. D. McIlvaine, Jr., University of Alabama, presiding.

1. The Teaching of Depreciation to Engineering Students. P. T. Norton, Jr., The Kilbourne and Jacobs Manufacturing Company, Columbus, Ohio.

   Discussion:

   E. L. Grant, Stanford University.
2. Economic Aspects of Aircraft Design. E. C. Wells, Boeing Airplane Company.

Engineering Drawing

Meany Hotel.

O. W. Potter, University of Minnesota, presiding.

Business Meeting.

Committee Reports.

Election of Officers.

Engineering School Libraries

Student Union Bldg. (27).

Johanna E. Allerding, University of California, presiding.

Business Meeting.

George Westinghouse Award Committee

Meany Hotel.

H. E. Wessman, University of Washington, presiding.

Business Meeting.

Industrial Engineering (Joint with **Engineering Economy** and **Aeronautical Engineering**)

Program details given under **Engineering Economy.**

Junior Colleges

Meany Hotel.

D. E. Deyo, Walter Hervey Junior College, presiding.

Program to be announced.

Lamme Award Committee

Student Union Bldg. (27).

N. W. Dougherty, University of Tennessee, presiding.

Business Meeting.

Mechanical Engineering (Machine Design **AAPT**)

Program details given under **Physics.**

Mechanical Engineering (Machine Design Committee)

Raitt Hall (6).

L. C. Price, Michigan State College, presiding.

1. Does the Mechanical Engineering Curriculum Adequately Serve Its Graduates and Their Employers? S. H. Graf, Oregon State College.
2. Election of Division Officers.

Physics (Joint with **AAPT** and **Mathematics**)

Student Union Bldg. (27).

C. L. Utterback, University of Washington, presiding.

1. Employment of Physicists and Mathematicians in Industry. G. P. Brewington, Lawrence Institute of Technology.

Relations with Industry (Joint with **Electrical Engineering**)

Program details given under **Electrical Engineering.**

Tuesday, June 20

2:00 P.M. CONFERENCES

Chemical Engineering

Room 140, Bagley Hall (33).

J. S. Walton, Oregon State College, presiding.

1. How to Tell the Boss What He Ought to Know. M. Souders, Jr., Shell Development Company.
2. Discussion of the Content of an Engineering Curriculum. L. M. K. Boelter, University of California.

3. Research Requirements for M.S. and Ph.D. Degrees. J. L. McCarthy, University of Washington.

General Discussion.

Civil Engineering (Construction and Transportation Committees)

Room 214, More Hall (47).

R. L. Peurifoy, Texas A. & M. College, and J. B. Babcock, Massachusetts Institute of Technology, presiding.

1. The Curriculum in Construction Engineering—A Symposium. C. H. Oglesby, Stanford University; F. H. Kellogg, University of Mississippi, and R. L. Peurifoy, Texas A. & M. College.
2. Development and Program of the Institute of Transportation and Traffic Engineering at the University of California. H. E. Davis, University of California.
3. The Selection of Highway Engineering as a Career. R. H. Baldock, Oregon State Highway Engineer.
4. Inspection of Suspension Bridge Laboratory, University of Washington. F. B. Farquharson, University of Washington.

Electrical Engineering

Room 322, Electrical Engineering Bldg. (46).

E. M. Strong, Cornell University, presiding.

Theme: Electrical Engineering Textbook Symposium: the teacher, author, editor, and publisher meet.

1. W. L. Everitt, University of Illinois.
2. H. Skilling, Stanford University.
3. E. P. Hamilton, John Wiley & Sons.

Engineering Drawing

Room 409, Education Hall (16).

O. W. Potter, University of Minnesota, presiding.

1. Reasons for the Sequence in Teaching Drawing at the University of Southern California. L. R. Shruben, University of Southern California.
2. Graphics in Research. A. S. Levens, University of California.
3. Making Lettering Practice More Interesting. E. C. Willey, Oregon State College.

General Discussion.

Humanistic-Social

Room 329, Student Union Bldg. (27). Chairman to be announced.

Theme: The Teaching of the Arts to Engineering Students.

1. Common Element in Engineering and the Arts. D. G. Stillman, Clarkson College of Technology.
2. Other speakers to be announced.

International Relations Committee (Committee of ECAC)

Room 221, Student Union Bldg. (27).

H. O. Croft, University of Missouri, presiding.

Business Meeting.

Mathematics (Joint with **Physics** and **AAPT**)

Program details given under **Physics.**

Mechanical Engineering (Machine Design and Manufacturing Subcommittee)

Room 224, Guggenheim Hall (34).

E. L. Midgette, Polytechnic Institute of Brooklyn, presiding.

Theme: Machine Design and Manufacturing.

1. Teaching of Welding in Machine Design Courses. J. Heuschkel, Westinghouse Electric Corporation.
2. Teaching the Design of Couplings, Clutches, and Brakes. V. L. Mallev, Oklahoma A. & M. College.
3. Progress in Precision Casting. S. E. Rusinoff, Illinois Institute of Technology.
4. Election of officers of Machine Design and Manufacturing Subcommittee.

Mineral Engineering (Western Industry Program)

Room 211, Roberts Hall (48).

H. F. Yancey, Northwest Experiment Station, Bureau of Mines, Seattle, presiding.

1. Coal and Fuel Resources of the Northwest. J. Daniels, University of Washington.
2. Current Metal Mining Developments in the Northwest. D. L. Masson, Washington State College.

Physics (Joint with **AAPT** and **Mathematics**)

Room 56, Johnson Hall (32).

C. R. Wylie, Jr., University of Utah, presiding.

Theme: Applied Mathematics in Physics and Engineering.

1. Computing Machines and Their Applications. H. D. Huskey, Institute for

Numerical Analysis, National Bureau of Standards.

2. The Mathematics of Plastic Flow. Peter Gibbs, University of Utah.
3. Mathematics of Airflow Theory. Speaker to be announced.

Tuesday, June 20

6:00 P.M. DINNERS

Engineering College Research Council (Annual dinner of ECRC)

Student Union Bldg. (27).

F. M. Dawson, *Vice-President of ASEE*, State University of Iowa, presiding.

1. Business Meeting: Brief reports of officers and committees.
2. Address: G. A. Rosselot, Georgia Institute of Technology.

Humanistic-Social

Faculty Club (30).

H. R. Bartlett, Massachusetts Institute of Technology, presiding.

1. Human Possibilities of Engineering in a Democratic State. Carl Condit, Northwestern University.

Technical Institutes

Student Union Bldg. (27).

H. P. Adams, Oklahoma A. & M. College, presiding.

Theme: Technical Institute Relations with Engineering.

1. Presentation of first annual James H. McGraw Award for outstanding contributions to Technical Institute Training. Deans of engineering colleges are invited to attend.
2. Development of Technical Institute Accreditation. H. P. Hammond, Pennsylvania State College.
3. The Place of the Technical Institute Graduate on the Engineers' Team in Industry. M. M. Boring, General Electric Company.

Tuesday, June 20

6:30 P.M. SMORGASBORD DINNER AND GENERAL ENTERTAINMENT

Wednesday, June 21

9:30 A.M. GENERAL SESSION

Wednesday, June 21

12:30 P.M. LUNCHEONS

Civil Engineering

Raitt Hall (6).

Harry Ruby, University of Missouri, presiding.

1. Business Meeting and Committee Reports.

Evening Engineering Education (Joint with **Industrial Engineering**)

Student Union Bldg. (27).

H. R. Beatty, Pratt Institute, presiding.

1. The Industrial Engineering Program of the Boeing Aircraft Company, Seattle. F. W. Neale, Boeing Aircraft Company.

Industrial Engineering (Joint with **Evening Engineering Education**)

Program details given under **Evening Engineering Education.**

Technical Institutes

Student Union Bldg. (27).

J. T. Faig, Ohio Mechanics Institute, presiding.

1. Outline of Plans for Purdue's Technical Institute Teacher Training Program. M. R. Graney, Purdue University.
2. Technical Institute Student Development Through Extra Curricular Activities. N. Rimboi, Fenn College.
3. Publicizing the Technical Institute. J. S. Noffsinger, National Council of Technical Schools.

Wednesday, June 21

2:00 P.M. GENERAL SESSION

Wednesday, June 21

6:00 P.M. DINNERS

Aeronautical Engineering

Meany Hotel.

E. E. Brush, Texas A. & M. College, presiding.

1. What Is the Aeronautical Engineering Department's Function to Be? H. C. Martin, University of Washington.

Architectural Engineering

Student Union Bldg. (27).

Program to be announced.

Chemical Engineering
Meany Hotel.
H. K. Benson, University of Washington, presiding.
1. The Nature of Engineering. M. P. O'Brien, University of California.

Engineering Drawing
Raitt Hall (6).
O. W. Potter, University of Minnesota, presiding.
1. Reading For Fun. E. H. Adams, University of Washington.
2. Report of Awards Committee.
3. Report of Resolutions Committee.

English
Meany Hotel.
F. Abbuhl, Rensselaer Polytechnic Institute, presiding.
1. A Field Theory for Us Too. P. G. Perrin, University of Washington.
2. Business Meeting and Election of Officers.

Executive Board (Closed meeting for Old and New Members of Executive Board)
Meany Hotel.
Thorndike Saville, *President,* New York University, presiding.
Business Meeting.

International Night
Student Union Bldg. (27).
H. O. Croft, University of Missouri, presiding.
Conference of International Guests to follow.

Mathematics
Meany Hotel.
C. R. Wylie, University of Utah, presiding.
1. Non-Linear Mechanics in the Engineering Curriculum. S. A. Jennings, University of British Columbia.

Mechanical Engineering
Faculty Club (30).
H. A. Bolz, Purdue University, presiding.
1. Big Science, Big Business, and Big Government. Wilson Compton, Washington State College.

Relations with Industry
Student Union Bldg. (27).
E. C. Koerper, A. O. Smith Corporation, Milwaukee, Wisconsin, presiding.
1. Annual Report.
2. Next Year's Plans.
3. Nomination of New Officers.

Wednesday, June 21

8:00 P.M. CONFERENCES

English
Meany Hotel.
F. Abbuhl, Rensselaer Polytechnic Institute, presiding.
1. Speech for Engineering Students. A. J. Fear, Seattle, Washington.
2. An Experiment in the Use of Real Engineering Reports in a Technical Writing Course. J. A. Walter, University of Texas.
3. How to Read Freshmen Themes. J. H. Pitman, Newark College of Engineering.
4. The Letter of Application—An Effective Aid to the Graduating Engineer. I. Cornet, University of California.

General Discussion.

Evening Engineering Education
Room 329, Student Union Bldg. (27).
M. C. Giannini, New York University, and S. E. Winston, Illinois Institute of Technology, presiding.
Theme: The Needs for Evening Engineering Education.
Panel Discussion:
1. F. R. Neuffer, University of Cincinnati, Panel Leader.
2. D. Foley, Boeing Airplane Company, Seattle.
3. R. W. Van Houten, Newark College of Engineering.
4. H. Torgensen, New York University.
5. M. M. Chamberlain, University of Washington.

Executive Board (Old and New Members)
Meany Hotel.
Thorndike Saville, *President,* New York University, presiding.
Business Meeting.

Industrial Engineering
Room 322, Electrical Engineering Bldg. (46).
J. A. Apple, Michigan State College, presiding.
Theme: The Industrial Engineering Curriculum.
1. Panel Discussion: The Industrial Engineering Curriculum.
Topics to be covered:
a. General or Basic Engineering Core.
b. Industrial Engineering Core.
c. Other courses.

Panel Leader: C. E. Bullinger, Pennsylvania State College.
Panel Members: To be announced.

2. Business Meeting.

International Night

Student Union Bldg. (27).

H. O. Croft, University of Missouri, presiding.

Mechanics

Room 214, More Hall (47).

Glenn Murphy, Iowa State College, presiding.

Theme: Contents of Materials Courses.

1. A Modified Sequence in Teaching Mechanics of Materials. E. G. Popov, University of California.
2. A New Type of Course on Engineering Materials. J. Marin, Pennsylvania State College.

Discussion:
H. P. Hammond, Pennsylvania State College.
C. O. Heath, Oregon State College.

Relations with Industry

Room 224, Guggenheim Hall (34).
E. C. Koerper, A. O. Smith Corporation, Milwaukee, Wisconsin, presiding.
Theme: Engineers, Jobs, and Placement.

1. Developing Profession Competence in Industry. J. C. McKeon, Westinghouse Electric Corporation, East Pittsburgh, Pa.
2. A Fundamental Approach to Engineering Job Specifications. E. N. Baldwin, Pennsylvania State College.
3. A Pattern for College-Industry Forums. M. J. Bergen, E. I. du Pont de Nemours Company, Newark, Del.
4. A Pattern for Regional Placement Associations. K. A. Meade, General Motors Corporation, Detroit, Mich.

Thursday, June 22

9:30 A.M. CONFERENCES

Engineering College Administrative Council (General Meeting) (Joint with **Relations with Industry**)

Auditorium (Division of Health Sciences) (63).
L. M. K. Boelter, University of California, presiding.
Theme: Engineering Employment in 1950.

1. Supply of Engineering Graduates. H. H. Armsby, U. S. Office of Education.
2. Available Positions for Engineers. M. M. Boring, General Electric Company.
3. The Employment Opportunities in Small Businesses for Engineers. A. R. Hellwarth, Detroit Edison Company.
4. Opportunities for Professional and Technical Personnel in the Federal Services. K. C. Harder, Navy Department.
5. Opportunities for Foreign Study in Engineering. W. R. Woolrich, University of Texas.

Civil Engineering (Structural Committee)

Room 224, Guggenheim Hall (34).
P. M. Ferguson, University of Texas, presiding.

1. What Program for Young Instructors? Frank Kerekes, Iowa State College.
   Discussion: H. E. Davis, University of California.
2. The Gap Between Research and Practice in Reinforced Concrete and Classroom Instruction. L. H. Corning, Portland Cement Association.
   Discussion: H. J. Gilkey, Iowa State College.

Civil Engineering (Surveying and Mapping Committee)

Room 309, Anderson Hall (50).
A. J. McNair, Cornell University, presiding.

1. Surveys and Mapping in Canada. G. S. Andrews, Assistant Director, Surveys and Mapping, Victoria, B. C.
2. Surveying and Mapping Methods Peculiar to Western Forest Areas. J. Frankland, U. S. Forest Service.
3. Modern Mapping Methods. G. Fitzgerald, U. S. Geological Survey.
4. The $6,000,000 Mapping Program for California. R. T. Wing.

Educational Methods (Subcommittee on Teaching Aids)

Room 224, Guggenheim Hall (34).
C. W. Muhlenbruch, Northwestern Technological Institute, presiding.

1. Facilities for Demonstration Lectures in Electrical Engineering. S. G. Lutz, New York University.
2. Theoretical and Design Considerations of Teaching Aids. V. A. Valey, U. S. Air Forces Institute of Technology.
3. A Proposed Program for Reviewing and Cataloging Teaching Aids. N. L. Reglein, John Wiley & Sons.
4. Demonstration Panel of Reviewing Procedure.

Industrial Safety, Hygiene, and Fire Prevention

Room 317, Guggenheim Hall (34).

J. J. Ahern, Illinois Institute of Technology, presiding.

Theme: Safety and Fire Prevention—Hallmarks of Good Engineering.

1. Industrial Safety in West Coast Engineering Schools. J. H. Mathewson, University of California.
2. Must There be Another College Residence Hall Fire? J. J. Ahern, Illinois Institute of Technology.
3. Progress Report on Accident Prevention Courses in Engineering Schools.

Junior Colleges

Room 214, More Hall (47).

D. E. Deyo, Walter Hervey Junior College, presiding.

Program to be announced.

Relations with Industry (Joint with **ECAC**)

Program details given under **ECAC.**

Young Engineering Teachers

Room 329, Student Union Bldg. (27).

F. L. Schwartz, University of Michigan, presiding.

1. Organization of Committee.
2. Business Meeting.

Thursday, June 22

12:30 P.M. LUNCHEONS

Aeronautical Engineering

Meany Hotel.

E. E. Brush, Texas A. & M. College, presiding.

1. Business Meeting.

Architectural Engineering

Student Union Bldg. (27).

Program to be announced.

Cooperative Engineering Education

Student Union Bldg. (27).

H. L. Minkler, Illinois Institute of Technology, presiding.

1. Business Meeting.
2. Report by Committee on Standardization of Merit Rating Forms.
3. Report by Committee on Relations with Federal Agencies.
4. Election of Officers.

Educational Methods

Meany Hotel.

E. A. Walker, Pennsylvania State College, presiding.

1. Business Meeting and Election of Officers.

Engineering College Administrative Council (Closed Meeting of Executive Committee)

Student Union Bldg. (27).

F. E. Terman, Stanford University, *Vice-President,* presiding.

Business Meeting of Executive Committee of ECAC.

Graduate Studies

Student Union Bldg. (27).

J. H. Rushton, Illinois Institute of Technology, presiding.

1. Aims and Objectives of Graduate Education in Engineering. A. F. Spilhaus, University of Minnesota.
2. Election of Officers.

Mechanics

Raitt Hall (6).

Glenn Murphy, Iowa State College, presiding.

1. Business Meeting and Election of Officers.

Thursday, June 22

2:00 P.M. CONFERENCES

Aeronautical Engineering

Room 317, Guggenheim Hall (34).

E. E. Brush, Texas A. & M. College, presiding.

1. Teaching Methods and Practices. Ezra Kotcher, USAF Institute of Technology.

Architectural Engineering

Room 309, Anderson Hall (50).

Program to be announced.

Civil Engineering (Joint with **Graduate Studies**)

Program details given under **Graduate Studies**

Educational Methods (Student-Faculty Evaluation Committee)

Room 56, Johnson Hall (32).

P. K. Hudson, University of Illinois, presiding.

Theme: Faculty Evaluation.

1. A Report on Student-Faculty Evaluation Programs. E. H. Gaylord, Ohio University.

2. A Report on the Faculty Viewpoint. G. G. Lamb, Northwestern University.
3. A Report on Administrator-Faculty Evaluation Programs. H. W. Case, University of California.
4. Panel Discussion:
   C. J. Freund, University of Detroit, Chairman.
   L. M. K. Boelter, University of California.
   H. P. Hammond, Pennsylvania State College.
   J. T. Rule, Massachusetts Institute of Technology.
   T. Saville, New York University.
   R. D. Sloan, Washington State College.

Engineering College Administrative Council

(Note: This meeting will begin at 2:30 P.M.)

Room 221, Student Union Bldg. (27).

F. E. Terman, Stanford University, presiding.

This meeting open only to official representatives of institutional members. Deans of engineering are the official representatives of member institutions.

Graduate Studies (Joint with **Civil Engineering**)

Room 224, Guggenheim Hall (34).

H. E. Wessman, University of Washington, presiding.

1. Relative Merits of Four Year Undergraduate Plus One Year Optional Graduate Study Compared to the Five Year Program. T. H. Evans, Colorado A. & M. College.
2. Nuclear Engineering. A. E. Gorman, Atomic Energy Commission.

Humanistic-Social

Room 101, Thomson Hall (17).

S. W. Chapman, University of Washington, presiding.

Theme: Human Relations in Industry.

1. A. A. Hemenway, University of Washington.
2. Other speakers to be announced.

Industrial Engineering

Room 322, Electrical Engineering Bldg. (46).

E. Laitala, University of Illinois, presiding.

1. Panel Discussion: Graduate Study in Industrial Engineering.
   Panel Leader: R. T. Livingston, Columbia University.
   Panel Members: To be announced.
2. Panel Discussion: Who Should Study Industrial Engineering.
   Panel Leader: G. A. Speer, Illinois Institute of Technology.
   Panel Members: H. R. Beatty, Pratt Institute; W. G. Ireson, Illinois Institute of Technology; E. C. Koerper, A. O. Smith Corporation, Milwaukee.

Junior Colleges (Joint with **Technical Institutes**)

Program details given under **Technical Institutes.**

Mathematics (Joint with **Mechanics**)

Program details given under **Mechanics.**

Mechanics (Joint with **Mathematics**)

Room 131, Bagley Hall (33).

A. L. Miller, University of Washington, presiding.

Theme: Aims and Objectives of Mechanics Course.

1. The Development of a Graduate Program in Engineering Mechanics. D. H. Young, Stanford University.
2. Appraisal of Prerequisite Courses.
   Opening Discussion: F. C. Smith, University of Washington.
3. The Mechanics Syllabus.
   Opening Discussion: E. M. Horwood, University of Washington.

Technical Institutes (Joint with **Junior Colleges**)

Room 231, Student Union Bldg. (27).

K. L. Holderman, Pennsylvania State College, presiding.

Theme: Joint Interests of Junior College and Technical Institute Divisions.

1. The Need for Technical Institute Graduates. H. P. Rodes, University of California.
2. Uniform Certification of Technical Institute Graduates. K. L. Holderman, Pennsylvania State College.
3. The Place of Technical Institute Graduates in Automotive Servicing. W. W. Squier, Sun Electric Corporation.

Young Engineering Teachers

Room 329, Student Union Bldg. (27).

F. L. Schwartz, University of Michigan, presiding.

1. Relationship Between Deans and Instructors. R. E. Vivian, University of Southern California.
2. Engineering Education Seminar at Stanford University. D. L. Trautman, University of California.
3. Needs of the Young Engineering Teacher. L. A. Clayton, Oregon State College.

Thursday, June 22

7:00 P.M. ANNUAL DINNER

Edmundson Pavilion (76)

Friday, June 23

9:30 A.M. CONFERENCES

Aeronautical Engineering

Room 317, Guggenheim Hall (34).
E. E. Brush, Texas A. & M. College, presiding.

1. The Market for Aeronautical Engineering Training. Kenneth Razak, University of Wichita.

Architectural Engineering

Room 103A, Architecture (Physiology) Hall (29).
Program to be announced.

Cooperative Engineering Education (Joint with **Relations with Industry**)

Room 214, More Hall (47).
H. R. Bintzer, Drexel Institute of Technology, presiding.

1. The History of Cooperative Education. M. B. Robinson, Fenn College.
2. An Interpretation of the Manifesto—Aims and Ideals of Cooperative Education. C. J. Freund, University of Detroit.
3. Cooperative Education—Its Success in Industry. R. Weller, Naval Missile Test Center, Port Mugu, California.

Engineering College Administrative Council

Room 125, Thomson Hall (17).
L. M. K. Boelter, University of California, presiding.
Theme: Review and Analysis of Techniques Used for Predicting Undergraduate Enrollment.

Engineering College Administrative Council

Room 101, Thomson Hall (17).
Joint Meeting, Committee on Student Selection and Guidance and Committee on Secondary Schools.
E. D. Howe, University of California, presiding.

1. Panel Discussion: Pre-Engineering Guidance at the Secondary School Level.
2. Tests and Testing Programs of Interest to Engineering Schools. A. P. Johnson, Educational Testing Service, Princeton, N. J.
3. Psychological Tests as a Predictive Index for Scholastic Success in Engineering Study. D. W. Taylor, Stanford University.

General Council Meeting (Closed meeting of Old and New Members of Council)

Room 329, Student Union Bldg. (27).
Thorndike Saville, *President,* New York University, presiding.
Business Meeting.

Graduate Studies

Room 309, Anderson Hall (50).
E. Weber, Polytechnic Institute of Brooklyn, presiding.
Theme: Industrial Fellowships for Graduate Study in Engineering.

1. Industry Viewpoint. M. J. Bergen, DuPont Chemical Company, Wilmington, Delaware.
2. Government Viewpoint. E. R. Piore, Office of Naval Research, Washington, D. C.
3. University Viewpoint. W. L. Everitt, University of Illinois.
4. Panel Discussion:
   H. E. Wessman, University of Washington.
   J. S. Walton, Oregon State College.
   R. G. Folsom, University of California.

Relations with Industry (Joint with **Cooperative Engineering Education**)

Program details given under **Cooperative Engineering Education.**

Friday, June 23

12:30 P.M. LUNCHEONS

Division and Committee Chairmen (Old and New Chairmen of Divisions and Committees)

Student Union Bldg. (27).
B. J. Robertson, *Vice-President, ASEE,* University of Minnesota, presiding.
Business Meeting.

COMMITTEE MEETINGS

Monday

Executive Board Business Meeting, 10:00 A.M., Faculty Club.

General Council Business Meeting, 6:00 P.M., Seattle Yacht Club.

Sections and Branches Committee, 12:30 P.M., Student Union Building.

Nominating Committee, 2:00 P.M., Room 221, Student Union Bldg. (27).

Tuesday

George Westinghouse Award Committee, 12:30 P.M., Meany Hotel.

Lamme Award Committee, 12:30 P.M., Student Union Building.

International Relations Committee, 2:00 P.M., Room 221, Student Union Bldg. (27).

Wednesday

Committee on Improvement of Teaching, 12:30 P.M.

Executive Board (Old and New Members), 6:00 P.M., Meany Hotel.

Friday

General Council Business Meeting (Old and New Members), 9:30 A.M., Room 329, Student Union Bldg. (27).

Division and Committee Chairman (Old and New Members), 9:30 A.M., Student Union Building.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Michigan	Wayne University	May 20, 1950	H. M. Hess, Wayne University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	University of Maryland	May 6, 1950	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13, & 14, 1950	F. H. Thomas, University of Buffalo

New Members

BALL, W. H. WARREN, Instructor in Electrical Engineering, University of Buffalo, Buffalo, N. Y. R. J. Costello, S. S. Wagner.

BALLARD, JOHN H., Assistant Professor of Chemical Engineering, University of Southern California, Los Angeles, Calif. R. C. Brinker, H. G. Conley.

BEER, FERDINAND P., Associate Professor of Mechanics, Lehigh University, Bethlehem, Pa. W. J. Eney, P. F. Miller.

BOYD, HARWELL L., JR., Instructor in Industrial Engineering, Georgia Institute of Technology, Atlanta, Ga. D. B. Wilcox, C. B. Focs.

BRIGHTBILL, LINWOOD J., Assistant Professor of Architecture, University of Washington, Seattle, Wash. D. G. Radcliffe, T. W. Macartney.

CAREY, JOHN J., Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. A. H. Lovell, W. H. Hedrich.

CARTER, GEORGE W., Associate Professor of Mechanical Engineering, University of Utah, Salt Lake City, Utah. W. J. Cope, P. J. Waibler.

CHENOWETH, HARRY H., Instructor in Civil Engineering, University of Washington, Seattle, Wash. R. B. Van Horn, A. L. Miller.

CHIPAK, ROBERT F., Instructor in Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. L. F. Stauder, C. R. Egry.

CHITTENDEN, HIRAM M., Associate Professor of Civil Engineering, University of Washington, Seattle, Wash. R. B. Van Horn, A. L. Miller.

CLARK, LYLE G., Instructor in Engineering Mechanics, University of Michigan, Ann Arbor, Mich. W. W. Hagerty, E. L. Ericksen.

COFFEY, JOHN W., Professor, Ordnance Dept., United States Military Academy, West Point, N. Y. B. W. Bartlett, R. I. Heinlein, Jr.

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Editorial—How Does the Society Operate?

By ARTHUR BRONWELL, *Secretary, A.S.E.E.*

Professor of Electrical Engineering, Northwestern University

How is the Society organized and how does it function? What is the Society actually doing to fulfill its mission of improving engineering education? How can I take an active part in the affairs of the Society? What is the procedure for submitting a paper for presentation at a meeting or for publication in the JOURNAL?

These are a few of the inquiries received from time to time which suggest that a reconnaissance survey of the operations of the Society might be beneficial.

Three Councils

The principal governing bodies of the Society include three Councils—the General Council, the Engineering College Administrative Council, and the Engineering College Research Council.

The General Council is a representative body which contains elected representatives from each of the twenty-one Divisions and sixteen Sections of the Society, in addition to the Society's officers and three past presidents. This Council has final authority over all regional and instructional activities. All problems of broad Society interest and all major undertakings, which are not specifically delegated to the other two Councils, are referred to the General Council. It meets twice a year, usually in November and June.

The Engineering College Administrative Council (ECAC) has supervision over matters relating to the administration of engineering colleges. Its activities include studies of selection and guidance policies, college faculty problems and policies, studies of the supply and demand of college graduates, relationships between engineering colleges and the government, and international relations of the Society. Membership in the ECAC consists of one delegated member from each Institutional member of the Society.

The functions of the Engineering College Research Council (ECRC) are to assist colleges in developing research facilities, to further advanced study, and to help coordinate research programs of industry and government as related to engineering colleges. The ECRC serves to keep administrators of research informed on the latest policies and developments affecting their interests. Membership in the ECRC is restricted to Institutional members of the Society which are actively engaged in engineering research. Both the ECAC and ECRC have meetings in the Fall of the year and at the Annual Meeting in June, at which time papers are presented on subjects dealing with college administration and research. The Chairmen of the ECAC and ECRC are Vice-Presidents of the Society.

The activities of all three General Councils are coordinated through the Executive Board, which consists of the President, four Vice Presidents, Treasurer and Secretary of the Society.

Divisions, Committees, Sections and Branches

The Divisions correspond to the areas of curricular instruction in engineering colleges. They are national in scope and their officers are elected each year at the Annual Meeting of the Society. The Divisions are largely responsible for planning the program of the Annual Meeting.

Most of the Divisions have their own working committees and several have their own technical publications, which are circulated among members of the Society in their curricular area.

Committees of the Society are appointed by the President, upon authorization of the General Council or Executive Board, to study problems and submit reports on matters of broad interest to the Society. Many contributions of first magnitude importance have resulted from such committee activities. Committees are also appointed in curricular areas where there is insufficient membership to justify Divisional status.

The Sections contribute in a very significant way to the work of the Society in bringing the Society activities to the regional geographical areas. Each Section has at least one meeting a year, at which papers are presented by local faculty members. Section meetings offer an excellent opportunity for participation of younger faculty members, since the transportation cost is usually nominal. The dates and location of Section meetings are published monthly in the JOURNAL.

A number of colleges have instituted Branches of the Society to assist in improving engineering education within the college.

Individual Participation

The accomplishments of any professional society are proportional to the interest, zeal, and enlightened effort put forth by its members. This Society has justly earned a preeminent position among engineering and educational societies of this country. Its democratic organization makes it possible for persons of all academic ranks to become officers of the Society, members of the General Council, or officers of Divisions, Sections or Branches.

Any member can offer a paper for presentation at the Annual Meeting or at a Section meeting merely by sending a copy of the paper to the Chairman of the Division or Section. Most of the Divisions and Sections rely on voluntary contributions, so don't wait for an invitation.

Any member of the Society may submit a paper for publication in the JOURNAL, regardless of whether or not the paper has been presented at a formal meeting of the Society. These papers are sent to the Publication Committee for review and recommendation. Papers should be sent to the Secretary. They should be typed double-spaced, written in good style, and any drawings or illustrations should be in form suitable for reproduction. It is well to remember that publication costs are extremely high and space is limited, so not all papers can be published. Authors should keep the number of pages to an absolute minimum and should avoid introducing excessive background material.

A detailed report of the major undertakings and accomplishments of the Society would be too lengthy here. However, members can keep posted on the Society activities by reading the minutes of the General Council and Executive Board meetings which are published in the JOURNAL.

Cooperative Engineering Education at the Graduate Level, from the Viewpoint of Industry*

By T. M. LINVILLE and K. B. McEACHRON, JR.

Assistant to Manager, Engineering Apparatus Dept. & Manager, Technical Education Division, General Electric Company

The Field for Postgraduate Education

The needs of industry for technical personnel are extremely diverse, ranging from those with a bachelor degree in a single field to those with study beyond the doctorate in several fields. In general, however, those with advanced college training are required in relatively few numbers for work in specialized fields such as research. A high percentage of the technical graduates employed by industry are, therefore, men with no training beyond the bachelor degree. Many of these graduates will use their engineering training as a basis for development in other work in industry rather than in highly technical engineering, while those who continue to be interested in highly technical fields will gain additional knowledge and understanding by industrial experience. In no case does education cease when the graduate enters industry.

However, there is a need for continuation of education in a more-or-less formal sense, not only because industrial progress depends upon it but also because technical graduates wish to advance themselves. Therefore, industry has a responsibility to provide for postgraduate education in one way or another. Many of the larger companies have met this need by organizing extensive educational programs of their own. For example, the advanced technical programs of the General Electric Company have served to develop men capable of solving the most difficult engineering problems. So well have such programs served the Company that they are, and perhaps always will be, depended upon to provide the postgraduate training of the men who will solve its design and development problems. This paper, however, is concerned only with those educational services which can be provided cooperatively by the colleges and industry.

Since engineering education is the keystone of the engineering profession, engineers either in industry or in teaching must work closely together to improve such education at all levels. The learning which identifies the members of the profession, the system through which it is taught to young men aspiring to enter the profession, and the practice of engineering itself are inseparable professional parts.

While in college, young men concentrate on understanding the fundamentals of engineering and on acquiring certain techniques or skills. Considerably more than technical knowledge must be absorbed, however, because college graduates have an obligation to use their superior training for the benefit of society in all areas. To conserve the time of these young men and to develop their earning power early, additional knowledge, such as of the humanities, must be efficiently acquired. Most college graduates can obtain such additional education

* Presented before the Graduate Studies Division at the Annual Meeting, Troy, N. Y., June 22, 1949.

most effectively by combining with it productive work in industry.

As a rule, the graduate entering industry is not very certain in what particular activity he will find his place, whether in development, design, manufacturing, application, sales, employee relations, advertising, or some other function. In a few of the larger companies, technical graduates are recruited for a general group from which they are later transferred to subsidiary organizations or departments. During the year or so that these men are in such a general group, they are employed in actual productive work. In most cases, assignments of a few months each to various operating units give them an opportunity to become familiar with units of the company in which they may eventually be placed, at the same time they are doing productive work—in other words, they are "learning by doing."

Industry's Part in Training the Engineer

In addition to work experience, such new employees are given some form of orientation course to acquaint them with their new surroundings, the organization of their company, its purposes and policies, and above all, to show them the paths of opportunity and challenge that are available to them. During this period other general educational needs include an extension of training in the application of fundamentals to the solution of engineering problems, and some further understanding of the business and economic areas. After this orientation period, training for functional areas such as engineering, manufacturing, and sales is provided. Such training emphasizes the interdependence of these functions as well as the importance of financial control and cost accounting. In the simplest business, these functions may all be performed by one man, while even in the large business any man is strengthened by an understanding of all functions. Functional training can be begun almost immediately by small companies. In the larger companies the graduate enters one of the subsidiary departments and begins functional training as soon as he has become familiar with the company's products and organization.

In addition to this general program for new technical graduates, the most able graduates are selected for advanced training to develop men capable of solving the most difficult problems. Although such advanced training has been almost exclusively confined to technical fields, there is a growing recognition of the value of providing advanced training in other fields as well.

Occasionally, some training is required on a still more advanced level for a very few men, usually those who have already been with the company some years and have attained positions of technical or executive responsibility. Such men should be provided with freedom to seek learning wherever appropriate centers of advanced study may be found. These men might be classed as industrial scholars.

Industry-College Cooperation

Recognizing the need to continue education beyond the undergraduate level, the colleges and industry can work together in several ways to develop courses at the postgraduate level. The discussion will be confined to education for engineering responsibilities with the understanding that similar arrangements could also be made in the other functional areas such as sales, manufacturing, etc.

Company Operated Courses

To assist industry in the effective conduct and improvement of company-operated educational programs, the part-time employment of college instructors is helpful. The college reduces the teaching load of these instructors to balance the load given by industry. Remuneration of the instructors is preferably arranged through the college, with an extra allowance for the essential part played by the college itself in making the arrangement possible. The growing dis-

persion of large companies is increasing interest in these possibilities.

Such an arrangement appears to require nothing more than a simple business contract. Nevertheless, a college and company should work cooperatively to plan each educational course. The two will naturally tend to develop courses which may eventually lead to a formal or informal cooperative program.

Courses conducted by a company under a contract with a college usually have no standing for degree credit and will usually be scheduled outside of working hours.

College Extension Courses

Courses operated by the colleges in recognition of general industrial needs will usually be considered for credit toward advanced degrees. The industrial employee usually wants degree credit for as much of his class work as possible, particularly for that taken outside of working hours. From the company's point of view, however, the value of the course as it affects the employee on the job is of primary concern. Colleges located in industrial centers can meet a real need by offering out-of-hours courses for ambitious technical graduates. Such courses may well be directed chiefly to broadening the education of engineers along the lines of history, government, labor relations, and economics, fitting them for greater responsibilities than are open to narrow specialists. In certain cases, the company may wholly or partly reimburse the student for tuition fees on successful completion of the course.

Postgraduate College Courses for Employees on Leave

Difficulties are encountered when a company considers sending employees to college for graduate studies. Except in special cases such persons cannot be treated as employees while in full-time residence at college. The employee's job at the company must be filled while he is away, and he may lose his place in the normal line of promotion.

However, the need of industry for a few highly capable individuals practically requires that men who have gained a high standing in industry should return to college for extended periods to carry on advanced study. It has been this practice in Europe that has fostered the development of top-flight scientists many of whom have come to America and have gained recognition as outstanding scientists here. This flow cannot be expected to continue and it is imperative that men be developed in this country to fill this need. One way to accomplish this is for industry to return to the colleges a few men each year for independent study.

Such men, returning to college in their mature years, should not undertake any specific course of study, or work for any degree credits necessarily, but rather should pursue their own research objectives developed from their industrial experience, doing some teaching also if they so desire. Logically, such men will gravitate to those university centers where leading scientists are already established, as only these will have much to offer in the most advanced training.

Having no specific courses to take, they can arrange to return periodically to company headquarters for consultation and can keep in touch with programs in which they are interested. This procedure has been followed in a few cases with notable success in England, Sweden, and elsewhere abroad.

Cooperative Postgraduate Education

This program offers an alternative to the "on-the-job" and "off-the-job" programs previously described, and can be used to handle a considerable number of graduate students. Under this plan, the colleges normally operate the schedules in the same way as for undergraduate cooperative students, the program being arranged to keep a constant number of men at each participating company at all times, alternating with others who spend the in-between periods in the college.

This plan provides a more gradual transition from concentration on education to concentration on productive work than is otherwise possible.

Short-Term Postgraduate Seminars

For many years, colleges have given so-called "short courses" in the field of agriculture for men who could not spare the time to attend full-length courses. In recent years, a similar plan for industry has been organized by the colleges to treat various aspects of economics, employee relations, or management. Bringing key industrial people together for seminars of from two to twelve weeks has been of great value. A fruitful area for such seminars might be the study of employer-employee relations within the engineering profession itself.

Graduate Projects of Interest to Industry

Industry always has at hand numerous analytical and experimental problems which could be considered as theses projects for men in graduate schools. Such problems should be made available to the colleges, but to accomplish the most effective results close association is essential between industry and the colleges with frequent interchange between faculty members and industrial engineers respectively responsible for such projects. Contracts between industry and college faculties for work on industrial problems is a fairly common arrangement which often leads to these projects of practical as well as academic value. We do not believe alert faculties should lack for suggestions for these subjects.

Fellowships

Many individual companies or groups of companies have established fellowships for advanced work in the colleges. Industry could greatly expand the opportunities for advanced study by providing fellowships for its own employees who would be given leaves of absence to carry on such study. In this way, industry would contribute to the extension of knowledge and to broadening the horizons of science.

Professors' Conferences

The importance of keeping teaching staffs alert brings up another field for cooperative programs at the graduate level, i.e., cooperative programs for faculty people. Many of the best teachers do part-time consulting work, conduct research or other investigations resulting in published papers, participate in sessions of technical societies, or spend time in industrial employment. Just as seminars held by the colleges for industrial leaders are valuable, so are professors' conferences held by industry important.

Industrial Lectures

A similar result can be accomplished in part for graduate students as well as their teachers through lectures at the colleges by industrial leaders. A fixed series of lectures by a number of men in different fields will probably be more effective than single isolated ones. In this case, the tendency for students to flock to new fields at the expense of older and often larger and more important fields may be minimized. The stimulation obtained from dynamic leaders in particular fields should be a significant experience.

Conclusion

Cooperation between industry and the colleges is not only desirable but is necessary to extend most effectively engineering education beyond normal college programs. As more and more industrial units come to realize the direct benefits to them of continuing the education of their technical and professional employees, it is obvious that industry must look increasingly to the colleges to provide such educational service. The colleges are best equipped with staff and facilities to give such postgraduate education. Industry on the other hand requires specialized and varied educational programs

designed to meet particular needs. Without close cooperation between the two groups the courses developed will be of little value to industry and will waste the time and money of all three groups, industry, the colleges, and the student-employees.

With industry and the colleges working together continuously to improve educational services, there will result not only greater industrial progress and more effective educational institutions but also an engineering profession better able to serve society.

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The Union and the Engineer[1]

By E. LAWRENCE CHANDLER

Assistant Secretary, American Society of Civil Engineers

Development of Collective Bargaining

One of the fundamental reasons—perhaps the chief one—for the existence of labor unions is to develop effective means for establishing agreements between union members and their employers to further what employees believe to be their best interests in such matters as working conditions, hours of work, and compensation.

Collective bargaining processes began in the United States more than a century ago. As far back as the 1820's there were a few local unions. However, their activity was sporadic and rather desultory. There was no statutory regulation. In 1881, the American Federation of Labor was established and unionism began to expand more rapidly.

Approximately at the turn of the century, came another incentive for unionization—the advent of mass production on a large scale. The techniques of mass production brought increasingly large industrial organizations and with them a major change in methods of management. The one-time shop or factory, in which the owner was the manager and the boss of ten, twenty or perhaps a hundred employees, gave way to industrial organizations owned by thousands of stockholders and requiring thousands of workers, with a board of directors and salaried management interposed to direct operations. Individual employees lost their identity to a large extent and completely lost contact with the owners.

These factors, coupled with the use of automatic machinery, standardization of products, and standardization of labor processes, presented what appeared to union leaders added need for regulating the performance of labor and they were not slow in stepping into the field.

So, came further expansion and with it inauguration of vertical unions in the new industries. In general, A. F. of L. unions had been based on the crafts, each composed of members having common interests by reason of the particular skills and working conditions incident to their jobs. On the contrary, the vertical union aims toward company-wide, or even industry-wide, coverage as exemplified in the Congress of Industrial Organizations. The chief mutuality of interest among members of a company-wide union lies in the circumstance of having a common employer and a common place of employment. Obviously, such a group may contain employees with wide divergencies of skills and interests. The resulting heterogeneity became one of the principal aggravations in the dilemma of professional employees later on.

In the 1920's and 30's, statutory protection of labor unions developed and this gave them further encouragement. Passage of the Wagner Act, in 1935, provided the crowning stimulus and the unions grew apace, until today there are something like sixteen million dues-paying members in recognized trade unions.

The National Labor Relations Act of 1935 (Wagner Act) provided full-blown guarantee of the right of labor to organize and bargain collectively and protected labor unions against specified "unfair

[1] Presented at the meeting on "Development of the Young Engineer," sponsored by the Committee on Relations with Industry, at the Annual Meeting of the ASEE, Troy, N. Y., June 20, 1949.

labor practices" on the part of employers. That Act continued in force without change until 1947, when the Labor-Management Relations Act, 1947 (Taft-Hartley Act), substantially modified its provisions in a number of important respects.

All these labor laws have been directed toward improving the status of "employees," and professional employees are just as much subject to their provisions as any others.

Prior to passage of the Taft-Hartley Act, the Wagner Act was the most important of the labor laws, especially to professional engineers. It was the purpose of the Wagner Act to guarantee to employees "the right to self organization, to form, join, or assist labor organizations to bargain collectively through representatives of their own choosing, and to engage in concerted activities for the purpose of collective bargaining, or for mutual aid and protection."

The Plight of Engineers Under the Wagner Act

For many years, labor unions contented themselves with efforts to organize the trades and common labor. However, in 1918 the A. F. of L. amalgamated a group of technicians and sub-professional men into the International Federation of Technical Engineers, Architects, and Draftsmen's Unions (IFTEA and DU). In 1933, a group of independent unions of technicians organized the Federation of Architects, Engineers, Chemists and Technicians (FAECT) and affiliated with the C.I.O. Later, it was absorbed into the United Office and Professional Workers of America, C.I.O. It is estimated that the two organizations now may have a combined membership of some 20,000. Although they have some professional members, they are heterogeneous in character. Some smaller organizations also entered the ranks of professional and sub-professional employees.

It was not impossible for a group of professional employees to form their own bargaining organization under the Wagner Act, but such action was complicated and difficult. As a result of the Act and interpretations and decisions of the National Labor Relations Board, professional engineers were required, in some instances, to join unions composed almost wholly of non-professional employees in the manual trades in order to hold their jobs. Other situations developed in which professional engineers found their collective bargaining right being claimed by unions with which they did not wish to be affiliated.

One of the best examples of what could happen is found in the case of the Shell Development Company, Inc., at Emery, California. In the early 1940's, 201 professional men, largely chemists, among whom were 44 with the degree of Doctor of Philosophy, found themselves about to be forced into a heterogeneous bargaining unit with a slightly larger number of non-professional employees. Among the latter were considerable numbers of roustabouts, janitors, window-washers, and the like. Quite appropriately, the professionals raised violent objection and a long-contested struggle ensued. With financial and legal assistance from the American Chemical Society, the case was fought to a finish before the National Labor Relations Board, the fortunate result being that the professional men succeeded in gaining recognition for an organization of their own and were able to stand by themselves.

A notorious situation arose at the Bloomfield, N. J., plant of Westinghouse Electric Corporation, where professional engineering employees were included in a heterogeneous group. Among other distressing developments, they were compelled to go out on strike, and their protests brought threats of reprisals. In spite of a petition for withdrawal, the National Labor Relations Board refused to grant their request for a separate unit under the Wagner Act. It was not until the Taft-Hartley Act opened the way that they finally succeeded in getting out of their predicament.

Such unfortunate circumstances were discouraging. There was definite need for engineers to be concerned about what went on in those years under the Wagner Act. The professional man does not fit into the kind of organization or modus operandi of most labor unions. The attitudes, abilities and work characteristics of a professional man just are not susceptible of standardization and regimentation in accordance with labor union criteria. It is a fundamental of labor union principles that quantity of work and compensation shall be standardized. This means that all, whether expert or inept, must be held to some standard of production, and obviously the standard must be at a low or mediocre level if it is to be within reasonable reach of all. Quite to the contrary, the aim of professionalism is superiority of production. It is folly to attempt standardization of the genius and abilities of creative artists or of professional engineers in the conduct of their professional work. Whatever merit labor union principles may have with reference to the performance and products of labor, they are not similarly applicable to professional services.

Regardless of idealism, the profession was faced with stern realities. Labor unions made increasing inroads on the ranks of professional employees during the years following enactment of the Wagner Act. The professionals were inept in the field of labor relations. Overwhelmed by the tactics of experienced union organizers and regardless of their wishes, they were likely to find themselves included in a heterogeneous bargaining unit almost before they were aware of what was going on. Once included, their protests usually were of no avail. Inevitably constituting a small minority in a large industrial organization, they were unable to choose their own representatives or to gain adequate opportunity to express their views. They became increasingly bewildered and discouraged. Evidence of the confusion was reflected by the number of disputes involving professional employees that came before the National Labor Relations Board.

Participation of Engineering Societies

It was natural for employee members to look to their national engineering societies for guidance and there developed a swell of demand that something be done to help them out of their plight. But, the field of labor relations was new to the professional societies. None knew what course to pursue, let alone how to pursue it. Some leaders in the profession advocated exemption for all professional employees but it became evident that a very large number of employees did not want exemption. Even if desirable, such a program would have required amendment of the Wagner Act and there was no likelihood of such an event in the early 1940's. One society went so far as to contemplate denying membership to any who took part in collective bargaining, but that program was abandoned when sober second thought indicated the manifest injustice that would have been inflicted on those who, frequently against their desires, had been included in bargaining units under rulings of the National Labor Relations Board.

Some valuable contributions resulted. The publication entitled "Technologists' Stake in the Wagner Act," produced by the American Association of Engineers, in 1944, gave a comprehensive record of experiences under the Act, set forth in detail an explanation of difficulties that had beset professional employees, and described steps necessary for the formation of appropriate collective bargaining groups. The American Chemical Society contributed a major pioneering service in its support of professional employees in the Shell Development Company case to which reference has been made.

Events appear to have demonstrated that the American Society of Civil Engineers followed the most consistently constructive course. As far back as 1937, the Society appointed a Committee on

Unionization whose function was to study the extent of unionization among engineers and recommend to the Board of Direction suitable courses of action. In 1941, the Society renamed its Committee the Committee on Employment Conditions and broadened its scope of action. As a result of recommendations from this Committee, based on its survey of experiences of professional employees with labor union organizations and after study of the legal aspects of collective bargaining, the Board decided, in 1943, to undertake a positive program to provide means for the development of "professional units." In essence, this was a purely defensive tactic.

Some opinion was held that the ultimate goal should be complete exemption of professional employees from coverage of the labor laws, but that did not prevail under the insistence of large numbers of employee members that they did not wish to be denied privileges granted to other employees. They wanted guidance in avoiding domination by labor unions and wanted to know how to exercise appropriately their privileges in employer- employee relationships.

Early in its deliberations, the Board of Direction concluded that the most desirable long-range objective would be changes in the labor laws which would, at the very least, prohibit the forced inclusion of professional men in labor-dominated bargaining units and which would permit them to refrain from collective bargaining if they choose to do so. Unfortunately, that was a hopeless task prior to the 80th Congress. The immediate problem, in 1943, was that of helping professional employees to meet their problems under the provisions of the Wagner Act.

Suggested Procedures

The Society published a manual, "The Engineer and Collective Bargaining," in July 1943, and later in the same year promulgated its suggested program.

Under the plan, preliminary steps of organization might be taken by a Local Section of the Society. In succeeding steps, Society participation became less and less, until, by the time a bargaining unit was created, the Society was entirely divorced from the proceedings. Not only was this procedure desired by the Society, it was a statutory requirement. Nothing is more fatal to recognition of a bargaining unit by the National Labor Relations Board than domination or influence by an employer and, since the Society is composed of both employers and employees, it is mandatory that it have no part in the functioning of a unit. The plan met with substantial success, as is attested by the fact that a number of professional engineering bargaining groups formed under its terms are currently in existence and functioning satisfactorily.

Looking forward hopefully to the time when there might be an opportunity to bring about amendment of the Wagner Act, the Society's Board of Direction adopted a statement of policy covering the principles deemed appropriate for the purpose. That policy was in three parts, as follows:

(1) Any group of professional employees, who have a community of interest and who wish to bargain collectively, should be guaranteed the right to form and administer their own bargaining unit and be permitted free choice of their representatives to negotiate with their employer.

(2) No professional employee, or group of employees, desiring to undertake collective bargaining with an employer, should be forced to affiliate with, or become members of, any bargaining group which includes nonprofessional employees, or to submit to representation by such a group or its designated agents.

(3) No professional employee should be forced, against his desires, to join any organization as a condition of his employment, or to sacrifice his right to individual, personal relations with his employer in matters of employment conditions.

As early as 1946, these principles were presented in a statement on behalf of the

Society to a subcommittee of the House Labor Committee of the 79th Congress. That was late in the session and nothing resulted except the planting of the seed.

The Taft-Hartley Act

Thus, the American Society of Civil Engineers, as a result of some ten years of intensive study and first-hand experience with the problems involved, and because it had adopted a definite policy, was in a position to provide the needed leadership toward amendment of the labor laws when opportunity presented itself during the first session of the 80th Congress.

Engineers Joint Council had been giving attention to the problem. Through its "Committee on the Economic Status of the Engineer," it had undertaken an intensive study of the whole field and published an excellent "Manual On Collective Bargaining For Professional Employees" in 1947. Council represents the American Society of Civil Engineers, the American Institute of Mining & Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Chemical Engineers. The National Society of Professional Engineers, although not a member of EJC, collaborated in preparation of the Manual.

In 1947, Engineers Joint Council adopted the before-stated principles as its official declaration of policy on which to frame legislative provisions in the interests of professional employees. Council established a Labor Legislation Panel for the specific purpose of presenting the matter to Congress. The National Society of Professional Engineers and the American Society for Engineering Education were invited to participate and each appointed a representative on the Panel.

Legislative bills based on EJC's officially adopted principles were introduced in both Houses of Congress, the bills being so framed as to cover the interests of all professional employees, not engineers alone. The Panel testified in support of the amendments before Labor Committees of the Senate and House. The American Chemical Society collaborated and presented a statement of its own. The effort was successful.

Obviously, the first problem involved was that of providing a satisfactory definition of "professional employee." Without a statutory definition, the National Labor Relations Board could have no firm basis on which to determine whether or not an employee should be classed as professional. The lack of any differentiating definition in the Wagner Act was a grievous stumbling block in cases where the Board undertook to assign separate coverage for a bargaining unit of professional employees.

Therefore, it was of tremendous importance to professional employees to have the following wording written in Section 2(12) of Public Law 101—80th Congress, the Labor-Management Relations Act, 1947, commonly referred to as the Taft-Hartley Law:

"(12) The term 'professional employee' means—

"(a) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learing or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or

"(b) any employee, who (i) has completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (a), and (ii) is performing related work under the supervision of a

professional person to qualify himself to become a professional employee as defined in paragraph (a)."

Section 9(b) establishes the principles under which professional employees are guaranteed the right to have units of their own if they care to do so. Following is a quotation from that Section:

"SEC. 9. (b) The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this Act, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof; PROVIDED, That the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unit;"

The essence of this is that a group of professional employees in any place of employment may decide, by majority vote of their own numbers, whether they want to form a unit of their own for collective bargaining purposes, to join with some other bargaining group, or to refrain from any action of the sort, if they so prefer. That is a far cry from the old Wagner Act conditions under which a group of laborers or production workers might form a collective bargaining unit and a few unfortunate professional employees might find themselves forced to become members or quit their jobs. At last, professional employees had statutory protection.

Present Status of Labor Legislation

With the current (81st) Congress came a great hue and cry from the Democratic Administration for repeal of the Taft-Hartley Act. Legislative bills to that end which were introduced in both Houses of Congress omitted all reference to the status of professional employees. If this Administration-sponsored legislation were to be enacted, professional employees would be thrown back into the same sorry plight they were in under the Wagner Act.

Realizing the possibility of losing all of the ground gained, Engineers Joint Council, as before, took appropriate steps to present the viewpoint of professional employees to the Committees of Congress. The Labor Legislation Panel was reconstituted with instructions that every appropriate effort be made to retain the pertinent provisions of the Taft-Hartley Act. A.S.E.E. and N.S.P.E. again participated. The Panel presented statements before the Labor Committees of Congress. Supporting testimony also was presented on behalf of independent bargaining groups of professional engineering employees.

As the result of bitter controversy in Congress over the major provisions of labor legislation, it appears likely that the Taft-Hartley Law will remain unchanged for the present.

Developments Under the Taft-Hartley Act

As a result of the Taft-Hartley Act, professional employees found themselves in a vastly improved situation. New opportunities were available, and with them, new responsibilities.

The stigma attached in the minds of professional people to collective bargaining procedures developed between management and labor during recent years has tended to make the very term "collective bargaining" offensive. Destructive strikes, violent picketing, limitation of productive effort, and the like, are measures far removed from the type of bargaining to which a professional man might subscribe.

It is to be noted that the provisions regarding professional employees are so written as to apply to all who may qualify under the definition of "professional employee." Already there have been cases of interest. One of the first had to do with a group of "time study" employees of the Worthington Pump and Machinery Corporation of Holyoke, Massachusetts. Although the National Labor Relations

Board was split in opinion as to the appropriateness of certifying such employees, the majority ruled that they were entitled to a collective bargaining unit of their own as professional employees.

In another case it was ruled that newspaper people—editors, re-write men, and reporters—are not professional employees under the definition in the Act, inasmuch as they are not required to undergo specialized training in an institution of higher learning. Again, attorneys employed by the Lumbermen's Mutual Casualty Company of Chicago were recognized as professional employees by the NLRB and formed their own unit.

Many other cases have been brought before the Board. Among the most interesting and significant have been requests for decertification by professional employees who had been included willy-nilly in heterogeneous groups under the Wagner Act and who, in some instances, had been unable to disentangle themselves in spite of determined effort. In several cases, such employees have succeeded in breaking away and now have their own units.

No dependable figure is available as to the number of professional engineering employees now included in collective bargaining groups, although the total is estimated at some 18,000 or 20,000. Somewhat more than half of these are included in units certified by the NLRB.

The movement has become widespread and continues to expand, with the greatest concentrations on the west coast and in the Philadelphia-New Jersey area.

General Comment

It is doubtless true that most professional engineering employees never will have the slightest interest in collective bargaining, even under the Taft-Hartley Act. The young man who enters the modest-size organization of a consulting engineering office probably will never give it a thought. It is not that sort of man about whom we are concerned. He has ready and close contact with his employer and, no doubt would much prefer to depend solely on his own abilities and initiative than submit to and be dependent largely upon group action for his advancement.

However, the situation is quite different in large industrial and manufacturing establishments. It is particularly the employees of such organizations that the Societies had in mind when they advocated the professional employee provisions of the Taft-Hartley Act. The rapid technological development of the country during the last two or three decades has been such that it is common to find hundreds of young scientists and engineer employees in one company. Obviously, there is not much opportunity for these men to maintain personal relations with their management. It appears that group action by professionals does have its place. What we are concerned about is that professional employees be permitted by statute to decide upon their own course without interference from others who have little understanding of their aims and standards.

It is earnestly to be hoped that whatever collective bargaining may be undertaken by engineer employees will be kept on a high plane. For action under the Taft-Hartley Act or any other law to be successful, or even tolerable, collective bargaining must be conducted in straightforward, dignified fashion, compatible with the ideals of professional people. Regimentation of performance should be avoided. Initiative and ambition of individuals should not be stifled. Tactics which tend to build antagonisms between employers and employees should be deplored. It appears to be true that some of the engineering groups formed to date have conducted themselves appropriately and in a manner beneficial to both employers and employees. That is as it should be and if future activity is kept in the hands of good leaders, results can continue to be constructive.

Too often, labor and management seem to have lost sight of the fact that they

must have a common ultimate goal if their enterprises are to succeed. When either fails to realize that the expediency of gaining some immediate objective falls short of best serving the general welfare, both suffer in the long run. Employers and employees alike have obligations to themselves, to each other, and to the community.

The subject of employer-employee relationships in industry is highly appropriate for class-room instruction or for discussion on the programs of Student Chapters of the Engineering Societies. Our young engineers should not be launched on their careers without some understanding of the human relationships involved. They need to give thought to the justifiable aspirations of labor and to the prerogatives of management, and to realize that they will find themselves somewhere between the two with problems, opportunities and responsibilities peculiar to their situation.

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The Problem of Transfer Students[1]

By HENRY H. ARMSBY

Vice President of ASEE, and Associate Chief of Engineering Education, U. S. Office of Education

This discussion attempts to indicate a few of the principal factors in the overall problem of transfer students, and some of the methods proposed or in use in attempts to solve them. It is based on the writer's experience in charge of admissions and guidance in an engineering college, on statements from a number of engineering deans, and on discussions with the Specialist for Junior Colleges in the U. S. Office of Education, who in turn consulted many junior college administrators.

Students transferring from one engineering college to another present no problems essentially different from those involved in a change of curriculum within a single institution. Those transferring from four-year-non-engineering colleges because of a changed educational objective generally are reconciled to an extension of their educational period, and appreciate the need for making up deficiencies in basic sciences and mathematics before being admitted to the engineering subjects of the last two years of engineering college.

Others in this group have in effect utilized the four-year college as a junior college, by attempting to secure a part of their engineering education in a non-engineering college, most often because of economic factors. These students present the same general problems as do junior college students; and the two groups will therefore be discussed as though both consist of junior college students.

[1] Condensation of paper presented before the Division of Engineering of the Association of Land-Grant Colleges and Universities, November 9, 1948.

Principal Problems

The main problems involved in the transfer of these students to engineering colleges are (1) the difference in length of curricula in the two types of institutions, (2) the great difference in their degree of specialization, and (3) the direct evaluation of credits, which might be called the mechanics of transfer.

Most junior colleges require for graduation from 60 to 66 semester hours, representing approximately one-half of the usual requirements for a degree in arts and sciences. Therefore, most junior college graduates have not had the equivalent of one-half of the requirements for an engineering degree. The engineering colleges are very definitely set against any reduction of graduation requirements, while the junior colleges are in many instances limited by their State departments of education or by their State universities from increasing the number of credit hours which they offer. Probably about all that can be done about this problem is to make sure that all concerned clearly and definitely understand what is implied by these figures. This is one element in the counselling and guidance service which should be rendered by both junior colleges and engineering colleges, which will be discussed later.

The second main problem connected with the transfer students, and the most important one, arises from the great difference in the degree of specialization between the junior college and the engineering college. The engineering colleges are organized to produce engineers, and in most institutions some specialization begins in the freshman year, and still

more in the sophomore year. The objectives of junior colleges, and of the community colleges which will undoubtedly be set up in increasing numbers in the not distant future, have been set forth in a recent statement of the National Council of Chief State School Officers. The statement lists candidates for technical and professional schools as a part of one of the five groups of students for which educational programs should be provided by these institutions.

It seems self-evident that the junior college cannot be expected to organize its entire curriculum for this small minority of its students, and that only the larger junior colleges can reasonably expect to enroll a sufficient number of pre-engineering students to warrant establishing special sections for them, and providing them with at least some of the specialized courses required in the first two years of engineering. Even here, however, conflict may arise between the graduation requirements of the junior college itself and the requirements of the first two years of engineering as now organized in most engineering colleges.

In the opinion of junior college authorities, this conflict could be at least materially lessened if the engineering colleges would give greater recognition to the importance of general education, if they would agree at least in general on what the basic subjects in the first two years of engineering should be, if they would clarify the meaning of and their acceptance of the A.S.E.E. recommendations regarding the humanistic-social content of engineering curricula, and more particularly if they would reorganize their curricula so that the general education subjects would be concentrated chiefly in the first two years and the technical and professional courses in the last two years.

One of the current trends in engineering education is toward an increased emphasis on general education. However, the prevailing sentiment among engineering educators favors the distribution of the humanistic-social content of an engineering curriculum throughout the four years, rather than a horizontal division at the end of the second year between general education and technical and professional education. They also believe that proper preparation for some of the engineering courses in the past two years requires a sequence of previous courses which cannot satisfactorily be covered in two years, and which therefore must be started earlier than the junior year.

Mechanics of Transfer

The third problem of the transfer students has to do with the mechanics of transfer—with the assignment of credit toward an engineering degree for work done in the junior college. Many junior college officials feel this should be handled on the basis of mastery of an area of knowledge, rather than on a basis of specific course for course transfer of credit. Many studies have shown, for example, that after the bare minimum essentials in mathematics and science have been met, the pattern of high school subjects studied has little or no correlation with success in engineering education, whereas the *quality* of high school work has a very high correlation with such success. They believe that the same principle applies to some extent all through the educational system, and that consideration should be given to the *quality* of work done by students, as well as to the subject matter.

Most engineering educators agree that almost any subject a student studies conscientiously has educational value, whatever his future profession or occupation may be, and that the fullest possible consideration should be given to past educational experiences of transfer students, and every possible allowance made for it in outlining requirements for their degrees. They should not be required to repeat work which they have already done, provided their knowledge is sufficient for the purposes for which a given subject is included in their curriculum. On the other hand, of course, it is no kindness to a student to permit him to register for courses for which he does not have suffi-

cient foundation. In other words, *real* prerequisites should not be waived for transfer students any more than for "home" students, but it should be certain that the prerequisites *are real* ones.

Methods of Improvement

The Junior College Specialist outlines three ways in which junior colleges might help the situation. He suggests first that the junior college should improve its counselling service, that it should give all the facts to its students, and show them exactly where they will stand if they attend the junior college for two years and then transfer to an engineering college. He points out that the junior college should be in a position to advise its students as to their future educational programs, to test and screen them, and to assist each in choosing the profession for which he is best fitted. This suggestion would undoubtedly meet with the wholehearted approval of all engineering educators, but it also has implications for them. In order for junior college officials to do this good job of counselling, it will be necessary that they *have* the facts to give their students, which means that the engineering colleges must cooperate with them and see that they *do* have the proper facts. Some college plans definitely recognize this obligation, and try to do something about it.

Second, he suggests that a junior college should offer only such engineering subjects as it is qualified to teach. This suggestion also will undoubtedly meet with the hearty approval of engineering educators. Several of the statements from engineering deans made the same suggestion, such as ". . . setting up an engineering curriculum—or any part of it—is not simply a matter of listing courses in a catalog, and finding just anybody to teach them. Professional training can only be given by persons specifically trained and experienced in the profession." The writer of this statement proceeds to point out, however, that while some of the junior colleges recognize this problem "few are in a position financially to do what should be done to effect a complete solution."

His third suggestion is that if the engineering colleges are to insist that they are professional schools starting with the freshman year and that they will accept only such transfer credits as fit their rigid requirements, then a junior college should not accept pre-engineering students unless it is prepared to meet these requirements. If on the other hand, engineering education can be so adjusted that it is based on a sound program of general education, as many kinds of professional education are, he feels the junior college can fit into the program. As desirable procedures toward this end, he mentions the evaluation of credits on the basis of areas of knowledge rather than specific courses, and the comprehensive examination, and feels that institutions which adopt five-year engineering curricula should be better able to integrate junior college curricula into their programs than those retaining the four-year curricula.

This view is echoed in some of the statements from engineering deans, one of whom says; "the two-year junior college has an excellent opportunity to fit into the professional school program because the curriculum of the latter is, in most cases, a rather common core of subjects for the first two years, with the real professional work beginning at the third year level . . . that some general agreement on a common core curriculum which might be offered by junior colleges for two years and which might be rather generally common for science and engineering schools in their first two years might make the transition easier and less expensive in time."

That engineering colleges in general are awake to the importance of the problems of the transfer student seems to be evident in the fact that nearly every engineering dean who was consulted by the writer outlined procedures adopted by his institution in an effort to solve these problems. Some of these procedures are:

The requirement of one semester of college credit for admission to the engineer-

ing school, with evaluation of credit handled individually, consideration being given to non-academic as well as academic experience.

Assignments of transfer credits by subject rather than by credit hours, with deficiencies made up by electives approved by the student's major professor, and with "general credit" assigned to courses not taught in the engineering college.

State-wide agreement among junior colleges and the engineering colleges, coupled with visits to the junior colleges by engineering college representatives. Several colleges report such visits and say that both the engineering colleges and the junior colleges expect transfer students after two years of junior college to complete an engineering curriculum in two years and one summer session.

Provision of definite and specific help to junior colleges—such as course outlines and worksheets, review and criticism of curriculum patterns, approval of instructors on the same basis as engineering college teachers, assistance in obtaining necessary equipment, suggestions for space arrangement in building plans, and actual loan of teachers on a leave of absence basis to initiate programs and supervise or teach for a year.

Establishment of extension centers offering the full first two years of engineering curricula, thereby making engineering education readily available to students in all parts of the State. The extreme of this arrangement is found at Penn State where all freshmen are "farmed out" to teachers colleges, privately supported colleges, and Penn State undergraduate centers. The freshmen are registered at Penn State, and their work is the same as it would be on the campus, so that no transfer problem is involved.

A Vital Problem for Engineering Colleges

The great growth in the number and enrollment of the junior colleges in the country which has already taken place, and the still greater growth which apparently lies immediately ahead, together with the great increase in public interest in engineering and science, all point up the urgency of improving the relationships between junior colleges and engineering colleges. It seems evident that the number of transfer students will continue to increase, and that both groups of colleges can expect increasing pressure to make some sort of provisions whereby the transition from junior colleges to professional schools may be made more easily and with less loss of the student's time. This will raise many problems for both groups of colleges.

The American Society for Engineering Education might well take an active interest in studying these problems nationally, and in attempting to promote the kind of cooperative efforts which will be necessary if any satisfactory solutions are to be reached. One section of A.S.E.E. usually devotes at least one session in its annual meeting to these problems. One engineering dean suggests that E.C.P.D. should inspect and accredit two-year pre-engineering curricula as well as those of technical institutes, and that "we would then admit without examination from such accredited institutions."

It is probable that the American Association of Junior Colleges would indorse a recommendation for inter-school studies, and would seek to enlist the active cooperation of junior colleges. The President of the Association of College Admissions Counsellors, an organization composed of representatives of 87 colleges and universities in mid-western states, has expressed an active interest in the problem.

The transfer student presents not a single problem, but a group of related ones, satisfactory solutions to which will not be easy. They will call for close and sincere cooperation between the engineering colleges and the junior colleges, both individually and collectively, especially in the provision of adequate guidance services by both types of institutions. It is the writer's belief that such cooperation can yield results well worth all the time and effort involved.

A Curriculum Leading to the Bachelor's Degree in Engineering Mechanics[1]

By H. J. GILKEY

Professor and Head, Department of Theoretical and Applied Mechanics, Iowa State College

Current engineering practice embraces three general fields of activity:

1. Professional: characterized by design, construction and maintenance along established lines.
2. Production and Management: industrial aspects; manufacture, distribution and sales.
3. Development and Research: exploration, experimentation and innovation; extension of fields of application; development of new products and processes; improvements in techniques of design, construction and maintenance.

Curricular cognizance has long been taken of the first, and more recently, of the second. Little or no planned effort has been made especially to prepare men for the third type of practice. It is proper that our major emphasis be directed toward the professional and production aspects for it is these which will continue to absorb most of the engineering college output, the run of the mill. As recent events only too well demonstrate, however, the field of development and research, in spite of the fewer numbers of persons involved, is enormously important. It seems probable that we have been remiss in having failed to recognize sooner that the need is not one adequately met by any existing curriculum. We have, in fact, been virtually forcing chemists and physicists to extend themselves far beyond any logical or justifiable boundary of scientific, as distinguished from engineering, activity simply because we engineers have fallen so far short in our coverage as to make it easier for the broadly but non-engineeringly[2] trained Ph.D. or B.S. in science to take over than for the narrowly trained engineering graduate to broaden his scientific base sufficiently to pick up where the scientist should, and normally would, have left off.

Specialization

With the curricular engineering eye focused upon its special type of professional practice, mathematics, chemistry, physics and mechanics are too often no longer even thought of as being foundation subjects, blocks of a broad, sturdy base; they have been and are being trimmed and divested of everything that fails to bear directly and narrowly on the particular brand of curricular specialization immediately ahead. Present curricular trends presume the civil engineer to have no interest in the physics that underlies thermo-dynamics; in the mechanics

[1] Presented at the Annual Meeting of the A.S.E.E., Mechanics Division, June 20, 1949, Troy, N. Y.

[2] Because of the current fetish for labeling as "narrow" everything that savors of engineering and accepting as "broad" virtually anything non-engineering, it needs to be emphasized that "broadly trained" and "narrowly trained" as used herein refer only to the relative breadth of the scientific and the technical aspects of curricula; they have nothing whatever to do with the so-called liberalizing areas. These comparisons refer to "fundamentals vs. specialized applications," not to the "technical vs. the liberal."

of any fluid other than water; in the problems posed by vibration, impact or fatigue; in the characteristics of any metal other than ferrous—and not much of that. The mechanical engineer is permitted an interest only in metals and his machine design is often made so empirical that it can parallel or even precede strength of materials and dynamics, which is, on occasion, also true for some of the civil engineering structures. The architectural engineer is interested only in building materials—their appearance more than their physical properties—and to the electrical engineer about two-thirds of physics, most of chemistry and all of mechanics could be deleted to the relief of all concerned.

In other words, the whole current trend, for some years past, has been for the curricular departments to assume ever increasing dominance over what were once considered to be foundation courses, reducing them in truth to "service courses" each one slashed and shaped to become nothing more than a small rung in the ladder of technical sequences that leads shakily upward to the "holy of holies" of curricular specialization. Breadth of base isn't wanted and will be largely ignored if provided.

Perhaps this trend is the correct one; perhaps it is sound engineering pedagogy to use the foundation as the quarry from which to secure more stone with which to elevate the parapet. The fact of present interest is that engineering education has come to be pointed so narrowly toward this Deity of upper-class professional specialization that the baccalaureate graduate has too often been schooled (not educated) in the use of formulas, handbooks and nifty techniques rather than in the application of principles; his foundation of emasculated physics and chemistry and of special-case mechanics lacks the breadth that is indispensable as a take-off for the type of thing that is bound to be encountered in Development and Research. Perhaps it isn't altogether accidental that neither Whitney nor Coolidge was educated as an engineer; that the first two degrees of Hardy Cross were earned at a non-engineering college; that so much of the development in such fields as those of structures, machine design, soils mechanics and hydraulics, has come to us by way of men educated abroad (and broadly), among whom are: Bakhmeteff, Timoshenko, Westergaard, Nadai and Terzaghi. Clearly we seem to have reached the point where engineering is confronted with the alternative of admitting a narrowed field or of extending its coverage.

Just as there exists the need for engineers with a broader, sounder grasp of the language and implications of science so is there a need for scientists better qualified to recognize and appreciate the engineering aspects of the problems and projects which grow out of their discoveries. The two are coordinate rather than competitive; the scientists can take over the engineer's job only at a price and the engineer, frequently, couldn't take over the scientist's job at any price. One concept of the engineer is a scientist with vertical bars through the S; the difference is economic and more. While not always tangible, the distinctions between the functions of the scientist and those of the engineer are, in our complicated civilization, as real as those between atomic theory and atomic power or between biology and babies.

Engineering Mechanics Curriculum

For us mechanics teachers there has always been a comfortable sense of impartiality in being able to say with regard to our undergraduate program: "We get all of the engineers but own none of them." About four years ago, however, Dr. Glenn Murphy and the writer became convinced that the engineering coverage must be strengthened on its basic-science flank; that until we engineers recognize and meet this obligation we may expect increasingly to find non-engineers floundering expensively in the engineering bailiwick. Just what the

new curriculum might be called (mechanics, basic engineering science, engineering physics, or general engineering science) was recognized as of little actual consequence; that it is content which counts and that the basic stem must be engineering not science with a little engineering seasoning. As one gets down to cases and tries to decide what should be omitted from existing curricula in order to make room for "more of the fundamentals" he begins to be for the moment a bit more tolerant of his curricular colleagues whom he has been accusing of wanton emasculation of "essentials" in favor of "specialties." The range of possibilities is wide and there is no combination of subjects that does not involve sacrifice and unwelcome compromise. After one has chiseled out a subject-size hole and struggled to decide which *one* of a half-dozen "fundamental musts" to use for it, he becomes more conscious than ever of the severe limitations imposed by the many competing demands on all of our undergraduate engineering curricula.

Steering clear, as previously indicated, of such perennially controversial incompatibles as: length of curriculum and humanistic vs. technical, we developed our proposed curriculum in mechanics to be of the same length (standard four-year) and to embrace the same amount of social humanistic content as did existing curricula. Our maneuverability is obviously limited in comparison with what would be possible in a curriculum of increased length, or one with less emphasis on the S-H stem. We started out by adherence to the common freshman year and introduced only minor changes in the sophomore year. There was, for example, a 2-hour per quarter sequence of: machine shop, metal casting and metal fabrication (fall, winter and spring quarters respectively). There were also included surveying and engineering geology, each for one quarter at 3 credits. With the junior year, essential differences developed and the curriculum began to get "tough," especially in the fall quarter. The following outlines supply an approximate indication of junior-senior year curricular content:

JUNIOR YEAR

Fall		Winter		Spring	
Dynamics	(4)	Mechanics of Materials	(5)	Fluid Mechanics	(4)
Differential Equations	(3 or 4)	Engineering Materials	(3)	Mechanical Vibrations	(3)
German	(3)	Materials Testing	(2)		
Thermodynamics	(4)	German	(3)	German	(3)
Kinematics	(4)	Thermodynamics	(4)	Elements of Structures	(5)
		Mechanical Laboratory	(1)	Electives	(3)

SENIOR YEAR

Fall		Winter		Spring	
Adv. Math. for Engrs.	(3)	Adv. Math. for Engrs.	(3)	Writing of Scientific Papers	(3)
Adv. Mech. of Materials	(4)	Adv. Tech. Statics	(4)	Plasticity	(4)
Techniques of Research	(2 or 3)	Techniques of Research	(4 or 5)	Techniques of Research	(4 or 5)
Development of Mechanics	(2)				
Technical Electives [3]	(4)	Technical Electives	(4)	Technical Electives	(4)
Non-Technical Electives	(2 or 3)	Non-Technical Electives	(2 or 3)	Non-Technical Electives	(2 or 3)

[3] Technical electives to be approved by the head of the department and at least one to be a 4-credit course in: electrical applications, machine analysis or machine design.

Description of Curriculum

With the student able to transfer into or out of the curriculum through the fall quarter of the junior year with practically no loss of credit, he there starts heavily into such fundamentals as thermodynamics, kinematics, structures and differential equations. The German is required throughout the junior year so that the student will have at least some reading knowledge available for use in his senior year. Russian or another appropriate language could be permitted as a substitution for the German when the course work in it is available and the library facilities justify. The new sequence, techniques of research, is proposed to acquaint the student with methods of proceeding on a new problem with a minimum of wasted effort from imperfect planning. It would include a study of outstanding engineering research problems which have been reported in the literature and a comprehensive report on a problem undertaken by the student. The junior-senior years together provide for at least fifteen hours of electives in approved fields of special interest to the student.

"Curriculum in Engineering"

No action was taken on this proposal of four years ago, but more recently a committee of the engineering college has been working on a curriculum which, if adopted, may be given some such label as: "Curriculum in Engineering" and would probably be administered, initially at least, by the Dean of Engineering. This too would have the uniform freshman year, including about 3 credits each quarter, of social-humanistics from such areas as zoology, psychology and history.

The sophomore year would involve little departure from the usual mathematics, chemistry, physics, economics and English courses but with omission of surveying and inclusion of: electric and magnetic circuits (5 credits) (W) and electric and magnetic fields (6 credits) (S). Statics comes in the winter quarter and dynamics in the spring quarter. Junior-senior sequences seem to be lining up somewhat as follows:

JUNIOR YEAR

Fall		Winter		Spring	
Alt. Current Circuits	(6)	Electronics	(5)	Heat Transfer	(3)
Thermodynamics	(4)	Thermodynamics	(4)	Thermo Lab.	(1)
				Fuels and Combustion	(4)
Mechanics of Materials	(5)	Materials Lab.	(2)	Properties of Materials	(3)
		Metallurgy	(3)	Fluid Mechanics	(4)
Non-Technical Electives	(3)	Non-Technical Electives	(3)	Non-Technical Electives	(3)

SENIOR YEAR

Fall		Winter		Spring	
Adv. Math. in Engrg.	(3)	Adv. Math. in Engrg.	(3)	Adv. Math. in Engrg.	(3)
Physics (heat)	(4)	Engrg. Measurement	(3)	Physics (optics)	(4)
Physical Chemistry	(3)	Physical Chemistry	(3)	Vibrations	(3)
Language	(3)	Language	(3)	Language	(3)
Similitude	(3)				
Technical Electives	(3)	Technical Electives	(6)	Technical Electives	(6)

Except as they might be elected this, like the earlier proposed curriculum in mechanics, contains none of the senior year terminal courses in design. Unlike the preceding, this curriculum is totally lacking in civil engineering subjects, including neither surveying nor structures. It is heavy in the thermo-heat power area; possibly too heavy.

The Department of Mathematics and

Mechanics at the University of Minnesota's Institute of Technology has just evolved a five-year curriculum leading to the degree "Bachelor of Engineering Mathematics."

The usual courses in chemistry, physics, drawing and mechanics are included in the first three years (including both differential equations and theory of equations). In the fourth year there are mathematical sequences of: vectors, dyadies and tensors; industrial statistics, a course entitled modern mathematics of engineering and one term of thermodynamics (3 quarter hours); three terms of humanities at 5 credits each and 3 terms of electives of about 4 credits each.

The fifth year has a 3-term sequence each of applied elasticity, advanced technical statics, modern physics and electives; a 2-term sequence of English; also a one credit, 1-term course in contracts and specifications.

As might be expected, this curriculum is weighted heavily on the side of mathematics. Like the current Iowa State College proposal, it is devoid of civil engineering subjects, but unlike it, it is also devoid of electrical engineering and virtually so of mechanical engineering. It is, as labeled, a curriculum in applied mathematics rather than one in engineering mechanics.

Other Approaches

Other institutions are toying with curricula representing various versions of the attempt to bridge the existing gap between engineering and science. In 1946 Cornell University announced a 5-year curriculum leading to the degree "Bachelor of Science in Engineering Physics," which like the preceding outline, savors more of science than of engineering.

A few years ago Purdue University merged its mechanics with civil engineering to form a Department of Civil Engineering and Engineering Mechanics. Under this administrative arrangement it offers under-graduate curricula in both fields.

Starting with the common freshman year, the nine-semester-credit summer surveying camp required at the end of the freshman year for the three Civil Engineering options, is waived in favor of a summer session at the end of the sophomore year for four credits each of Mechanics of Materials and Engineering Materials. Except for a three-credit course in Elementary Heat Power during the second semester, the sophomore year differs but negligibly from that for the Civil Engineering options.

The junior and senior years are as follows:

JUNIOR YEAR

First Semester		Second Semester	
Economics	(3)	Fluid Mechanics	(4)
Electrical Engineering for C.E.'s	(4)	Electrical Measurements of Non-Electrical Quantities	(3)
Strength Properties of Materials	(3)	Dynamics	(3)
Differential Equations	(3)	Advanced Engineering Math.	(3)
Thermodynamics	(3)	Expository Writing	(3)
Physics (intermediate optics)	(4)	Government	(3)

SENIOR YEAR

First Semester		Second Semester	
Applied Elasticity	(3)	Elements of Design (materials aspects)	(3)
Vibrations	(3)	Experimental Stress Analysis	(3)
Measurements with Electrical Aids	(3)	Theory of Elasticity	(3)
Numerical Methods of Analysis	(3)	Psychology for Engineers	(3)
Metallurgy	(3)	Metallography	(3)
Non-Technical Elective	(3)	Non-Technical Elective	(3)

This is obviously what it purports to be, a real curriculum in Engineering Mechanics. It gives heavy emphasis, perhaps rightly so, on the materials aspects of mechanics, somewhat in contrast to the tendency in many curricula to under-emphasize materials, especially the Properties of Materials. Many, including the writer, would question the advisability of not having the dynamics definitely a prerequisite for fluid mechanics, but that is a detail. While at Purdue, as at Michigan, the curriculum in Mechanics happens to have, administratively, a Civil Engineering linkage, there appears to be no more of a basic tieup there than with any other engineering curriculum; in other words, the curriculum offered is definitely, not a Civil Engineering option; it is essentially autonomous, or with slight alterations could be made so. Purdue has within the past year conferred its first baccalaureate degrees in mechanics. As expected the number of takers has been small, but the quality of students attracted is reported to have been high.

Michigan Experience

As has always been the case in schools having strong Departments of Mechanics, the major appeal is and may be expected to continue to be at the graduate level for students having various engineering baccalaureate backgrounds. At Michigan, for example (the pioneer institution to offer a bachelor degree in mechanics) there have been graduated since 1930: 33 bachelors, 67 masters, and 53 doctors. Of course this can be attributed in part to the "Timoshenko stimulus" but advanced degrees in mechanics have long been in demand at Illinois, Wisconsin, and various other schools without undergraduate curricula offerings in mechanics.

Looking further into the Michigan setup, we find it to be unique in its flexibility. Out of 140 semester hours, 66 are listed as preparatory; 27 as secondary, and 47 as advanced. The preparatory include (besides English, physics, chemistry, drawing, economics and non-technical electives) mathematics through simple differential equations and metal processing. The secondary group includes surveying, all of the usual undergraduate mechanics through fluid mechanics, a course in direct and alternating currents, one in theory of structures and a course in elementary thermodynamics.

The advanced courses include: advanced engineering mechanics 16 hours, advanced mathematics about 9 hours, instrumentation (electrical) 3 hours, electives 6 hours and approximately 13 hours in some specified technical engineering department, including an advanced design course.

One of the hurdles immediately confronting any curriculum which proposes to broaden its base at the expense of senior year design and specialization is the criticism that it does a good job as far as it goes but awards a degree short of design proficiency in any branch of engineering. In its previous accrediting program the E.C.P.D. took exactly that stand regarding some of the curricula in general engineering and industrial engineering and also in agricultural engineering, which it branded as neither agriculture nor engineering.

The Michigan setup is admirable for getting around this difficulty; perhaps too much so, inasmuch as the mechanics curriculum was actually accredited as an option of civil engineering; quite in contrast with some of the other proposed curricular layouts in which not one distinctively civil engineering subject appears. As outlined it seems that the Michigan curriculum might potentially be accredited under any of the three major branches: civil, electrical or mechanical, as determined by electives chosen.

Curricular Design for Accreditation

The Michigan plan, which seems in its operation for E.C.P.D. accrediting purposes, to have virtually amounted to a "basic science option in civil engineering," points to one possible way of meeting the current need without encountering

accrediting difficulties. This would be to add to Civil, Electrical and Mechanical Engineering (possibly others) a "basic science option." While such variants would not carry a mechanics label, each of them would be strengthened in mechanics and mathematics and the graduates from these options would be more favorably situated than their fellows for pursuing a mechanics major toward either the M.S. or the Ph.D. degree. An alternative would be to call all of them mechanics with options (or minors) in Civil, Electrical or Mechanical Engineering. These considerations are, however, essentially administrative.

While accrediting under established procedures and standards is an item, it should not be accorded too much weight. If what is evolved is good and proves itself by the quality of, and the demand for, its output it will not be long until it is recognized and accorded a place. Few if any new curricula can expect immediate acceptance at the hands of those affiliated with going curricula.

In attempting to introduce a new curriculum in mechanics or a related field several practical considerations should not be ignored. One is that virtually all course offerings must be from among courses already being given to other groups. Otherwise the cost would be prohibitive since, in spite of the need for people so trained, the number of persons taking the curriculum in mechanics may, for the entire forseeable future, be expected to be small. In the current Iowa State College proposal, for example, the committee recommends to the Dean that students to be eligible for enrollment in the curriculum be selected from the upper ¼ of the freshman class and counseled on its objectives before acceptance. With only top-flight students eligible and only a fraction of the eligible students interested in, or adapted for, such a branch of engineering, the enrollment would probably not exceed 5 per cent of the engineering undergraduates.

It is clear that the major occupational outlet would be research. To accomplish its objective the curriculum should qualify the B.S. graduate to take a place in his type of position on a basis comparable to that of his fellow graduates in other curricula. Nevertheless, any student who has measured up to the requirements of this version of the bachelor's degree is of graduate caliber and should be encouraged to continue his studies, as most of them may be expected to do. While a graduate of any of the recognized engineering curricula can take graduate work in mechanics virtually without loss of credits, the graduate in mechanics would inevitably be further along initially than would the others. On the other hand, it is not to be expected that a B.S. graduate in mechanics could work toward the M.S. degree in one of the other curricular branches without having to back up for several of the necessary and more or less specialized technical sequences. That is one point the student must recognize as he makes his choice, just as he must do the same when he elects civil engineering instead of electrical, et al.

Conclusions

In conclusion it appears that the time has now come for a new engineering curriculum designed to impart stronger basic training at the expense of specialization. Regardless of what it might be called or how it might be administered, it needs essentially to be a curriculum in engineering mechanics designed to develop men grounded in the fundamental principles which must necessarily form the basis for research and development. These men must have the viewpoint of the engineer rather than that of the physicist or chemist; they must have available mathematical tools beyond calculus, and they must understand and not merely have been exposed to engineering mechanics; they must be able to apply it broadly. Heretofore, that understanding of mechanics which comes from the reconsideration, the analysis, and the careful study of limitations and principles (necessarily

covered hastily in a beginning course) has been deferred to the graduate year. It is not felt that this curriculum is by any means a substitute for a four-year course in some standard engineering field, followed by a fifth year with a major in mechanics. It is felt, however, that for a student who is able to spend only four years in college, this curriculum offers an opportunity for him to prepare himself for a type of professional practice for which men are vitally needed but for which appropriate training is not available in other curricula. It also offers the under-graduate mechanics major an opportunity to go farther faster on his graduate program.

While our engineering attainments are not to be belittled, we can't afford to bask in achievements of the past. Just now the gap between that which we call engineering practice and the basic scientific stem, to which we owe our origin and upon which we are still dependent for technical sustenance, has become so wide as to have left us engineers far in the rear of "Science, The Endless Frontier." In the late war we did bull-doze a lot of dirt and presumably we designed and constructed the buildings that housed atomic research. It was admittedly a scientist's show but nevertheless one in which there were many important roles for which engineers were needed but couldn't qualify. For such curricula as those outlined it is apparent that the relatively few "takers" will come, not only from the stronger students, but also from a particular type of stronger students. On the other hand, there seems to be no question regarding the opportunities for those who qualify. Many of the larger industrial organizations indicate an eagerness for just that type of man: the non-specialized engineer with breadth of background. Men so qualified should also be much in demand in many of the government bureaus.

As a few of the recognized schools attempt to meet the current need, there is leeway for the exercise of considerable ingenuity and judgment in deciding just what the curriculum content should be and how it should be administered. This is a time for study and judicious experimentation rather than for attempted standardization. As regards the situation at Iowa State College, there has been no adoption of any proposed curriculum and anything that might eventually be done may well bear little resemblance to either of the programs roughly outlined herein. Thus far the proposals made represent nothing more than an effort to pool the judgments of a few individuals and are without official significance or status. Passing mention has been made of them simply to indicate that the subject is under consideration. An indication of the several directions the thinking has been taking may well prove constructively provocative of better thinking by others.

Oak Ridge Institute of Nuclear Studies

By RUSSELL S. POOR and A. D. JOHNSON

University Relations Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

Introduction

Scientists from all over the world are coming to Oak Ridge to receive training they cannot find elsewhere. This training is being provided by the Oak Ridge Institute of Nuclear Studies. But it is a joint endeavor of the twenty-four Southern universities which comprise the Institute's membership, of the Atomic Energy Commission, and of the Commission's industrial contractors in Oak Ridge. The Institute is the agency which knits these diverse groups into a new pattern of education.

Historically, the Oak Ridge Institute of Nuclear Studies is still in its swaddling clothes. It was conceived by a small group of Oak Ridge and Southern university scientists who early recognized the exceptional nature of the opportunity presented by Oak Ridge. Here were scientific research and training facilities unequalled in the world. It was an opportunity the like of which the South had never seen.

These interested scientists and educators gathered in Oak Ridge during their Christmas vacation of 1945 and laid the groundwork for the permanent organization of the Institute. Almost simultaneously, other university groups with similar aims, were organizing in the Northeast and the Middle West.

The Institute was chartered in October, 1946, and since that time it has constantly expanded its facilities in order to improve its services to the universities, the laboratories, and the nation as a whole.

How the Institute Works

The Oak Ridge Institute of Nuclear Studies is not a separate university, nor does it aspire to become one. Such a development would weaken rather than strengthen our educational system.

By law, only the government may own certain of the key atomic energy facilities. Moreover, atomic energy is a costly business—so costly that no university can afford to maintain the necessary equipment to carry out effective research and training in this important field. It is the primary aim of the Institute to make these Oak Ridge facilities available to all universities in this country which offer advanced training in the sciences. In this way, the atomic energy laboratories at Oak Ridge in effect become a part of the campus of each participating university. The laboratories in turn receive the stimulation of intimate contact with science in the academic world. Thus, the laboratories and the universities both are strengthened and the opportunities for scientific education are greatly increased.

The Institute holds a contract with the Atomic Energy Commission which calls on it to carry out a variety of programs in the Commission's facilities at Oak Ridge. It also maintains working agreements with the Carbide and Carbon Chemicals Corporation which operates the major Oak Ridge research and production facilities for the Commission.

Programs of the Institute

Graduate Training Program.—Selected graduate students from any university in the country may carry out the research required by their university for the doctoral degree in biology, chemistry, engineering, metallurgy, mathematics, and physics through this program. Students are brought to Oak Ridge on the equiva-

lent of a graduate fellowship upon application to the Institute by the university in which they are enrolled.

Radioisotope Training Program.—Radioisotopes have been called the most important research tool to be developed since the invention of the microscope. Here in Oak Ridge—the world center of radioisotope training and production—the Institute is training hundreds of research scientists, medical workers and others in the safe and effective use of this new tool. These courses already have been made available to American scientists and are now open to scientists from other nations which receive radioisotopes from Oak Ridge.

Research Participation Program.—Through this program university faculty members may come to Oak Ridge laboratories to conduct research for periods ranging from three months to a year, and even longer in unusual cases. This program benefits the laboratory by bringing into it fresh talent from the academic world. It strengthens the university by giving its staff members better training, and it gives the individual concerned an opportunity to keep abreast of developments in the atomic energy field.

Cancer Research Program.—The atomic energy program has brought into play new forces in the battle against cancer and other major diseases. In cooperation with twenty Southern medical schools, the Institute is now laying the foundation for a long-range study of the treatment of cancer and other malignant diseases. Special emphasis will be placed on the testing of the effects of atomic energy products on these diseases. This is a research program only and will not be open to the public for purposes of treatment.

Resident Graduate Program.—The most important part of the laboratories at Oak Ridge are the workers who man them. As a service function to the Commission, its contractors, and their employees, the institute and the University of Tennessee offer fully-accredited training in the sciences on the master's and doctor's level. This program is operated by the University through a sub-contract which calls on the Institute to provide the buildings and equipment and on the University to provide the teaching personnel.

Other Programs.—The activities of the Institute also extend into the Southern universities themselves. Arrangements are made under which members of the outstanding scientific staffs at Oak Ridge give lectures and conduct seminars at Southern universities. Three annual awards of $500 each are offered for the most significant research papers in the sciences to be written by staff members or students of its sponsoring universities. The Institute assists its universities in obtaining Commission support for their own research programs.

Research and Training Facilities

The Institute utilizes all of the appropriate facilities of the Atomic Energy Commission in its programs, although the majority of these facilities are actually operated by other contractors for the Commission. The principal facilities in Oak Ridge are set out in the following paragraphs.

Operated by the Carbide and Carbon Chemicals Corporation

Oak Ridge National Laboratory.—This is truly one of the world's greatest laboratories. Programs of research and training in biology, chemistry, engineering, metallurgy, mathematics, physics, and nuclear technology are carried out here. A uranium-graphite reactor is the major research tool. The reactor also produces most of the radioisotopes now being used in research around the world.

Research laboratories of the gas diffusion plant.—Here also are unique opportunities for research and training in physics, chemistry, and engineering. The gas diffusion plant is the major installation in this country for the separation of uranium isotopes.

Research laboratories of the electromagnetic plant.—Today, the production

facilities of the electromagnetic plant are on a standby basis, but important research programs are carried out in the laboratories. Stable isotopes are separated here.

Operated by the Fairchild Engine and Aircraft Company

The NEPA Project (Nuclear Energy for the Propulsion of Aircraft) is operated by the Fairchild Engine and Aircraft Company and associated contractors for the Army Air Corps. Many opportunities for research and training are being developed in this field.

Operated by the University of Tennessee

The University of Tennessee is establishing a large experimental farm on the Oak Ridge area to investigate the effects of radioactive materials on farm crops and animals, and to conduct fundamental research in the field of agriculture through the use of such materials.

Operated by the Oak Ridge Institute of Nuclear Studies

The Institute itself operates exceptionally well equipped laboratories for training in radioisotope techniques. It also maintains physics, chemistry, and biology laboratories and other facilities for its Resident Graduate Program. The Institute is establishing the necessary facilities in a wing of the Oak Ridge Hospital for the conduct of the cancer research program.

A.S.E.E. Sponsored Summer Schools

An Engineering Mechanics Summer School will be held at Iowa State College, Ames, Iowa, September 11–15, 1950. Correspondence concerning the Summer School should be addressed to Dr. Glen Murphy, 101 T. & A. M. Laboratory, Iowa State College, Ames, Iowa.

A Humanistic-Social Summer School will be held at the University of Washington, Seattle, Wash., on June 23, 24 and 26, 1950. If you plan to attend, please write to Professor Stuart Chapman, University of Washington, Seattle, Wash.

A Critical Evaluation of Cooperative Engineering Education*

By P. A. CARLSTONE

Education and Training Department, International Harvester Company, Chicago, Illinois

At the annual meeting of the Society last June, four representatives of industry presented to the cooperative engineering division their views on cooperative engineering education. A. R. Hellwarth of Detroit Edison, R. A. Deller, Bell Telephone Laboratories, and D. S. Roberts of the General Electric Company cited their experiences. S. R. Parry of Combustion Engineering-Superheater, Inc., reported the results of a survey given to 26 industries in the southeastern section of the United States employing cooperative engineering students.

All were agreed that the cooperative engineering program has many advantages. However, Mr. Parry, reporting the feelings of 26 companies, said he would "not discuss the advantages which were listed except to point out that practically all companies participating in this survey stated that the advantages to industry of cooperative engineering education far outweighed the disadvantages."

Mr. Roberts reported General Electric as "well pleased with the results shown by graduates of the M.I.T. program." As yet there have been no graduates from Rensselaer Polytechnic Institute or Cornell University. Therefore, no evaluation could be made of these programs.

Mr. Deller, speaking for Bell Telephone Laboratories, said, "I am sure we will all agree that certain benefits accrue both for the student and company. The student has industrial experience periods planned for him and practically assured. If the type of company and the job assignment are well chosen he is provided with a good view of the type of work toward which he is aiming. Also, assuming that he has done well in his assignments, he has built up assets leading to an offer of regular employment upon graduation. The company also derives certain benefits in that it develops a measure of the student's suitability and capacity for its work, thus supplementing materially what can be done by interview only. This benefit to the company, however, is not a unique feature of cooperative education. The same is accomplished by summer and other temporary assignments." Mr. Deller also observed that "when studying turnover data we have found that losses after regular employment initially introduced through the cooperative plan are much lower than that for other groups. Consequently, this result is a distinct benefit to the company."

Problem Areas in Cooperative Program

The main purpose of the meeting was to define certain problem areas in the field of cooperative engineering education and to learn how various companies have coped with situations within those areas. Thus, considerable attention was given to difficulties encountered in cooperative education—to some extent limiting discussion of the more successful aspects of such programs.

* This is a digest of papers presented on the subject, "Industry Evaluation of Cooperative Education Programs," by A. R. Hellwarth, R. A. Deller, S. R. Parry, and D. S. Roberts, at the Annual Meeting of A.S.E.E., Troy, N. Y., June 21, 1949.

Some concern was expressed over the coordination of work experience and school courses. In Mr. Hellwarth's opinion, "greater advantages would accrue from the student's experiences in industry if there could be complete coordination of his assignments and responsibilities at work with the courses taken in the preceding school period." Transfer to more difficult assignments effected during the later work periods would tend to give the student a more definite feeling of progress. General Electric places cooperative students on its regular Test Program, where their work assignments and college courses are as complementary and compatible with the students' interest as it is possible to make them. Cooperative students gain a great deal from their association with graduates of other universities during their work assignments.

Length of school and work periods was also discussed. Mr. Hellwarth felt that periods should be the same length, as it makes it possible for industry to schedule students in each work group on a continuous basis. He advocated a twelve-week interval, which reduces to a minimum the time spent in travel to distant work locations. Mr. Parry indicated that 87 per cent of the industries he surveyed preferred the three-month (twelve-week) period. Thirteen per cent favored the six-month period. Not a vote was cast for the four-, six- or eight-week interval. Companies responding to the survey recommended further that students be required to attend school for at least one year before entering the cooperative training phase of the course. All candidates for the General Electric program, according to Mr. Roberts, must have at least one year of college work before becoming eligible for industry assignments. The M.I.T. and Cornell programs at the General Electric Company provide for two years.

Student Selection and Student Adjustment

The selection of students for cooperative engineering programs provided another area for discussion. Mr. Hellwarth thought the coordinator should have a voice in the selection at the time a student enters college. It is the coordinator's responsibility to provide job opportunities for students. Among other things, the student should be employable by industry. Mr. Parry indicated that some companies believe they should be given more opportunity to select the students. Mr. Roberts pointed out that, in the General Electric programs, students are selected by both the school and the company.

Also considered was the problem of student adjustment to industry assignments. Mr. Hellwarth pointed out that a part of this adjustment to industry involves the breaking away from home ties. Many cooperative students attend schools within commuting distance of their homes, yet it is preferable that placement be in industry away from home. This forces them to adjust to strange environments and to manage their own personal affairs. Southern industry recommended that students not be permitted to change jobs without an investigation by the educational institution to determine if the change is warranted.

Here is where the coordinator can render valuable service to the student and the cooperating company. In Mr. Hellwarth's opinion, "the success of the cooperative plan depends largely on the work of the coordinators in both school and industry. These duties should be a part of their jobs and not just added to their work schedules already filled with other duties. Coordinators must have an interest in young people and their development, and should be well qualified as counsellors. It is their job to look ahead and see these young men taking their places of responsibility in industry and the profession." Excessive turnover in the course, Mr. Parry added, can be kept to a minimum if school and company representatives conduct frequent interviews with students to determine the areas in which there is dissatisfaction.

The speakers thought there should be

uniformity of requirements. Schools entering the field of cooperative education should use requirements already established by other schools. Then conditions of work and standards of performance will not vary when students from different schools are to work together. Written reports by students should be a common requirement. Industry reporting to Mr. Parry's survey want educational institutions to standardize their student report forms.

Lack of time may hinder cooperative engineering students from participating in social, athletic and other activities of college life. Carried too far, this can produce a warped personality. Mr. Roberts said that the General Electric program is flexible enough to allow students to hold office in clubs, and societies, play varsity sports, and, in general, participate in nearly all extra-curricular activities.

Operational Difficulties

The foremost disadvantage listed in the industry survey was student turnover. As things stand now, an individual industry is burdened with the expense of training cooperative students with no certainty, first, that they will remain for the full educational period, and, second, that they will choose to remain with that company upon graduation. Mr. Parry felt that industry and educational institutions can cooperate in correcting the first problem. The second must be worked out by the industry itself as the student progresses. An interesting angle to the problem was brought out by Mr. Deller, who stated that a cooperative engineering student missed the benefits derived from finding his own job. "The plan tends to limit him in the number of companies with which he works. When economic conditions are on the down-trend, he may be let down if assignments are cancelled. From the point of view of the company, difficulty may be encountered in providing work at times when employment of new people on a regular basis is restricted. . . . Then, too, the company should not overlook the value of experience periods gained in other types of work such as manufacturing and operations, when bringing new engineers to its development and research staff."

Other problems mentioned by the speakers included: the loss of efficiency caused by personnel changes between job and school; disadvantages of unbalanced section, and extra clerical and administrative work required; and the necessity for explanations of policy changes each time a student returns to his job.

Mr. Roberts made several suggestions for improving cooperative engineering education. For example, General Electric has been encouraging industry-sponsored thesis subjects. These theses, prepared while the student is on his industrial assignment, involve working out the solution to practical industrial problems. Both industry and the student stand to gain much from such projects. Mr. Roberts cited another example: "We have felt the cooperative student has not taken full advantage of getting to know the working man and woman. A goodly number of the assignments are in shop areas usually where equipment is being assembled. It is a golden opportunity to talk to the workers and thereby learn how they think and act. In general, they are fine people who are proud of their skills and their contributions to the product."

"Many of the students have missed the point that the best technical design may not produce the best product from a sales and consumer standpoint. The best design, of course from this standpoint, is the best product that can be produced at a figure that will bring reasonable profit to the producers and yet be priced such that the consumer will buy it. Much more effort is needed here to get this idea across."

Mr. Parry concluded his paper by making the following recommendations: "I am, without reservation, convinced after this survey that industry is not only wholeheartedly in accord with the cooper-

ative engineering educational program, but they are willing and desirous of meeting with the best possible plan for carrying on this work. I would strongly recommend that from time to time sectional meetings be held between employers of cooperative students and those in the colleges responsible for administering the program to discuss cooperative education and exchange ideas and make recommendations for improvement. I believe you would find industry willing to give their full support to such a program, and a lot of the disadvantages which exist could be eliminated; at least all parties concerned could come to a common understanding on them which would lead to a better partnership with industry on this matter of cooperative education."

Editor's Note

From time to time, there will be a page in this journal devoted to news and notes of cooperative engineering education. Why not continue this discussion on this page? Send us your problems in this field and the solutions you have worked out. If you need help on a problem, we'll be glad to submit it here for solution. This is your page. Send your news, suggestions, and ideas to P. A. Carlstone, c/o International Harvester Company, 180 North Michigan Avenue, Chicago 1, Illinois.

College Notes

Lehigh University has adopted a new five-year curriculum in electrical engineering and engineering physics. In establishing the combined program of studies, the faculty educational policy committee reported that the project was adopted to fill a special need. The combined curriculum is not designed to attract the average student but those with particular interests in the communications fields. In setting up the new program, the committee has established an equal number of required hours in electrical engineering, physics, mathematics, and the social sciences and humanities. A summer of industrial employment will be a requisite between the third and fourth years.

Heat Power Laboratory as a Preparation for Employment in Industry[1]

By B. J. ROBERTSON

Vice President of the A.S.E.E. and Professor of Mechanical Engineering, University of Minnesota

Because we are training students primarily for positions in American industry, the training in engineering schools should definitely be affected by the needs of these industries. A well-known industrial member of this Society says that "Too many times schools carry out a development program of laboratory and curriculum without the advice of people in industry." We are often guilty of lagging behind the needs of industry in the instruction we offer.

It is relatively easy to keep lectures and recitations in step with technical progress if the faculty is not adverse to changing text books and if it will take time to keep abreast of the information available to it from the technical literature.

But the problem of keeping heat power laboratory in step is difficult. Much of the equipment is large in size and requires elaborate and expensive piping and wiring if the installation is to be comparable in neatness and ease of operation with similar machinery when it is placed in service by industry. It may well be that the cost of the installation exceeds the first cost of the apparatus.

The Cost of Heat Power Laboratory Instruction

Because of the cost and the labor involved in making a change, such equipment is likely to remain in place on the laboratory floor for several decades. These obsolete machines may be adequate for demonstrating scientific principles, but the student attitude toward obsolete equipment is hardly enthusiastic.

Another factor contributing to the expense of heat power laboratory equipment is the poor utilization of space. Normally, a steam turbine or a Diesel engine may be used only a couple of afternoons in a week. Just at present, due to the large enrollment, we are all operating with better space efficiency, but large pieces of equipment are idle a large part of the working day—sometimes a large part of the week.

A number of suggestions on how the cost of equipment and space utilization can be reduced have been made by previous writers on this subject. N. C. Bailey and J. J. Devine (7) suggest using one large laboratory space for both Junior and Senior laboratories, using as often as possible the same piece of equipment for both classes and employing special modifications to suit the equipment to either Juniors or Seniors. Others urge less elaborate installations and leaving much of the laboratory set-up to the students themselves. This may reduce the quantity but may improve the quality of laboratory work. The introduction of unit-operation types of experiment are a part of Dean Boelter's plan (2) for senior mechanical engineering laboratories. Although not primarily designed for the purpose of reducing the cost of equip-

[1] Presented before the Mechanical Engineering Division at the Annual Meeting of the Society, Troy, N. Y., June 23, 1949.

ment, this system would be helpful because much of the equipment required would not become obsolete and the number of commercial type installations could be reduced. Professor Degler (3) estimated about ¼ of the mechanical engineering student's time is spent in the laboratory and that the expense of conducting this laboratory is from ⅓ to ½ of the total expense of his course. In view of the time and expense involved, the faculty have a responsibility to ascertain as far as possible the advantages and perhaps the need for laboratory work as it is now given. Some of the most able men engaged in technical engineering were educated as physicists and probably had no mechanical engineering laboratory experience. However, they developed an interest in mechanical engineering problems and soon acquainted themselves with the practical operation of machines and devices. This should not be taken as an indication that all engineers could be properly prepared without laboratory, however, we may well ask ourselves whether the expense to the school and the proportion of the students' time involved in performing actual experiments and in writing reports are always justified (5).

Importance of Heat Power Laboratory

Heat Power Laboratory may contribute to a well rounded engineering education in many ways:

When properly correlated with the text book and lecture it may be used to illustrate and fix basic principles in the students' minds (8). At the same time the differences between analytical predictions and experimental results impress the student with the limitations of simple theoretical analysis and the host of variables that always enter in the operation of a machine.

Having used a series of instrumentations for different experiments, the student has some idea of how to go about setting up instruments and devices to secure needed experimental data. If he is required to select instruments and set up some of the experiments in his more advanced heat power laboratory courses with little advice from the instructor he will have had some most valuable experience.

With proper supervision—not enough to make the work routine but enough to give the necessary help—the student should learn to handle instruments and other apparatus intelligently. He should learn that instruments have their limitations and how to check their accuracy. There is a tendency on the part of the student to blame the apparatus or the equipment for poor results when the real reason is stupid operation.

Experienced laboratory instructors know that careful supervision is necessary to secure consistent performance curves on prime movers. Such supervision deprives the group of the experience they are certain to need eventually if they enter the experimental or development field. It seems likely that errors sufficiently large to ruin an entire test may make that particular experiment more valuable in the education of the student, provided the source of error is determined, than one which came out exactly right because all of the equipment had been calibrated and properly set up and arranged for him before he began his work.

Although large equipment is expensive to operate, does not allow good laboratory space efficiency and lacks flexibility, a limited experience with such machines is desirable for engineering graduates. If a student has not watched the pressure gage rise higher and higher as the heat is applied to a steam boiler or has not had the experience of gradually warming up a steam turbine until it is safe to allow it to run at greater speeds, or if he has not heard the roar of an aircraft engine as his hand opened the throttle, he will lack confidence when he approaches similar machines in the course of his professional occupation (6).

It is customary in some laboratories to

assign a leader to a group handling an experiment. If this is not done, it will generally be found that there are one or two men who naturally take the lead in such groups. There may be some doubt as to whether the art of leadership can be promoted to any extent in a man who is not naturally a leader but those with an inclination toward leadership will certainly develop it.

There is perhaps no part of the work required of an engineering student about which students complain so universally as the writing of laboratory reports. The criticism is frequently voiced by graduates that the reports written in school are not representative of those required by industry. Since many of the reports used in the schools are for the purpose of explaining or discussing the relation between theory and practice which is definitely not the purpose of most commercial reports, this criticism is just. Professor J. H. Pound (1) mentions an attempt made at his school to bring the report writing in the school closer to commercial standards. It is likely that much can be done in this respect. Although English should be taught by those who know English—the English Department, any laboratory instructor knows whether a report is clear and concise, and types of commercial reports can always be had to indicate what industry requires.

The unfolding of new information inspires further work. When time in our laboratory work can be found for short theses on original problems, originality, inquisitiveness and resourcefulness may be inspired or developed in many students.

Many graduates do not enter the fields of development, research, or operation, and may never do any laboratory work after they have received their Bachelor's Degree. The experience they had in college laboratory may contribute materially to their understanding of development and research. Men without laboratory experience frequently reach important positions in administration. Because of lack of experience, they are impatient and unable to appreciate problems in development and research or to judge when the department of development and research is not functioning properly. Some of our largest industries are successful largely because of the understanding attitude of the administration toward a long-time program of research.

A Limited Survey of Engineering Graduates

We often entertain criticism from students regarding the courses they are taking when in school, but the more mature judgment of those who have completed school and have spent some years in engineering practice would be of greater value to us. With this thought in mind, a questionnaire covering the points just discussed in regard to laboratory work was prepared and sent to about 107 graduates in mechanical engineering from the University of Minnesota. In general, the names were picked from those in the highest one-third of their class. Seventy replies were received. The majority of them graduated in 1947 and 1948. The number of graduates in 1943–45 that could be contacted was relatively small, because the small number graduated were immediately scattered in the armed forces and war industries. There were about tweny-five older men who had been out of school ten to twenty-five years in the group. They were mostly employers or supervisors of engineers. All were asked to grade the possible contribution to their education made by their laboratory work in school as A, B, C, D, F, and to add any other contribution that they felt had been made and give it a grade also. Signatures to the questionnaires were optional, but they were coded so that we could tell the year the man had graduated. He was asked to add any remarks he thought might help us. The majority of the men signed their names, and fifty-eight out of the seventy added some very interesting comments.

The questionnaire was as follows:

To the extent indicated by the grade circled, heat power laboratory courses have contributed to:

	Grade				
1. The conception of the actual relationship between theory and practice, between analytical predictions and experimental results.	A	B	C	D	F
2. The ability to design and set up a combination of instruments and equipment to solve an experimental problem.	A	B	C	D	F
3. The ability to handle instruments and apparatus intelligently and to recognize the limitations of each piece of apparatus.	A	B	C	D	F
4. The ability to interpret results, recognize faulty data etc., and to develop methods either analytical or experimental to check the method being used.	A	B	C	D	F
5. Familiarity with machines, engines, or other prime movers so that one can work around them or operate them with some degree of confidence.	A	B	C	D	F
6. The ability to direct or assume leadership and responsibility in a group.	A	B	C	D	F
7. The ability to write clearly and concisely.	A	B	C	D	F
8. The writing of reports that are acceptable commercially in form and arrangement as well as composition.	A	B	C	D	F
9. The development of originality, inquisitiveness and resourcefulness.	A	B	C	D	F
10. An appreciation of the limitations involved in development and research. (valuable where one is engaged in administration, etc.) (and therefore, not active in laboratory work)	A	B	C	D	F
11. A better understanding of the limitations of equipment being sold and greater confidence in advising the prospective buyer on its operation, etc. (valuable when one's work is in sales without factory) (experience)	A	B	C	D	F
12.	A	B	C	D	F
13.	A	B	C	D	F

REMARKS: Please use the other side of this sheet.

I am engaged in Design, Research, Development, Sales, Management, ... work.

Discussion of Results

In Fig. 1, the answers from the questionnaires are divided into two groups—the older graduates and the more recent graduates. The grades given arrange themselves in the same general order with a preponderance of B grades except for the item "Development of Originality—Resourcefulness." There seems to be little difference between the opinions of the older graduates and the more recent ones.

In Fig. 2, the excess of A plus B grades over the D plus F grades are shown and arranged in order of descending values. The C grades are omitted with the thought that they express a median value and, therefore, may be omitted in evaluating the relative importance of the items in the questionnaire. It is clearly indicated that our graduates do not feel that the laboratory courses as now conducted contribute much to resourcefulness, inquisitiveness, etc. Also that students obtain little useful familiarity with machines in general. Report writing and relation between theory and practice, the handling of instruments, and interpretation of experimental results are apparently well thought of.

It should be emphasized that because of the small number of people contacted in this survey and because they are all graduates of the University of Minnesota an adequate picture of the laboratory situation has not been obtained. On the other hand, an examination of Professor Schwartz's paper (4) indicates that there is no great difference in the subject matter being treated in the majority of heat power laboratories. Furthermore, the

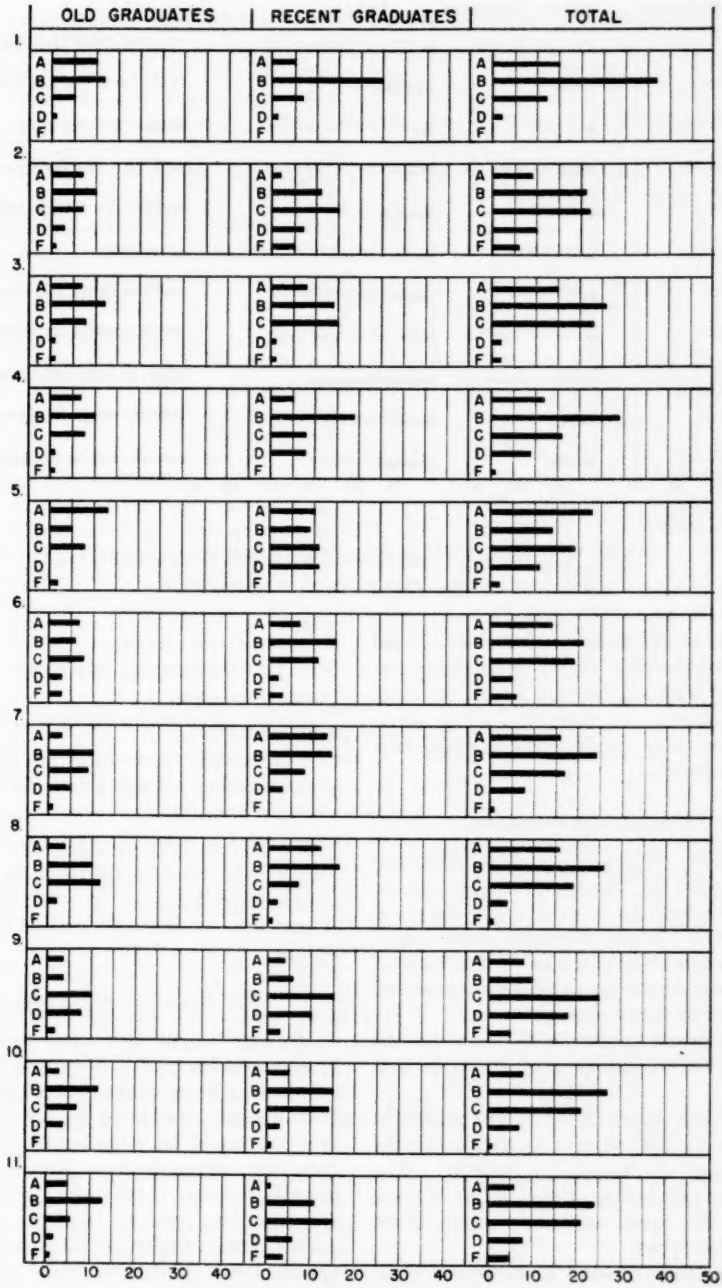

FIG. 1. Opinions of old and recent graduates.
Numbers at left refer to items in questionnaire.

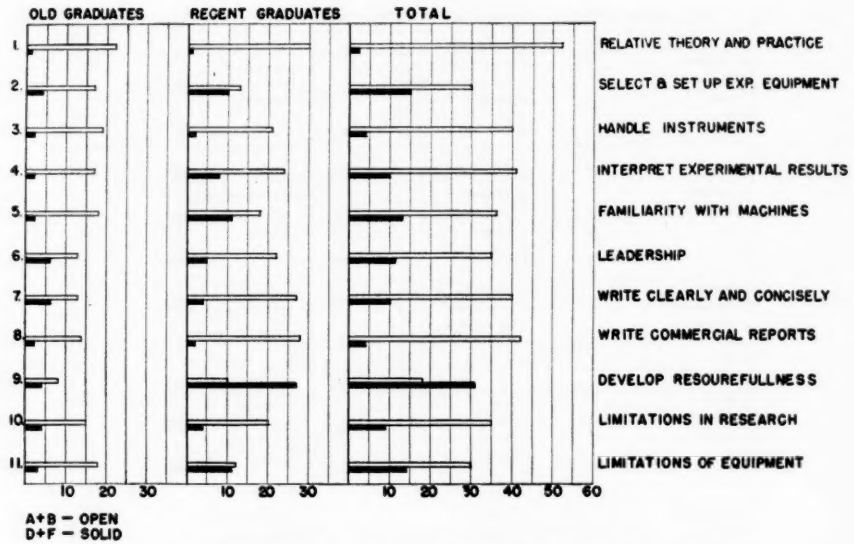

FIG. 2. Comparison of opinions of older and recent graduates. Numbers at left refer to items in questionnaire.

opinions of the older graduates are based to a considerable extent upon their experience with engineering graduates from many schools. It, therefore, seems probable that these results show a trend that may be general.

Remarks by Graduates

Perhaps the most valuable contributions made by the graduates are to be found in remarks accompanying the questionnaires. These remarks were sometimes a paragraph or two on the back of the questionnaire and sometimes consisted of a two or three page letter.

No one suggested a decrease in the amount of laboratory work given in heat power.

The most severe criticism was leveled at the use of old reports as guides or the copying of old reports by students. This situation probably exists in all schools where the same experiments are given year after year.

Perhaps the second most severe criticism was leveled at the amount of time required to prepare reports and the large amount of time required to earn a credit hour in laboratory as compared to other types of courses.

A third important criticism was that:

> "Laboratory procedures are stereotyped—not enough left to the student's initiative."

The most serious criticism of laboratory courses was their failure to develop originality, inquisitiveness, or resourcefulness. A criticism of this sort cannot be taken lightly.

The Opinion of Industries

Most of the questionnaires sent to our graduates were mailed in care of the chief personnel officers of the concern for whom they worked. In doing so, we suggested that we would be very happy indeed to have any comments from the industry on the effectiveness of laboratory work. The response was not as large as was expected, but is understandable because we specified one particular type of laboratory, namely, heat power laboratory.

There was, however, general agreement

among the comments by industry on the importance of the objectives listed in the questionnaire. In general, the criticisms offered are in line with the comments made by the engineering graduates. This is interesting because the comments of the men in industry were not directed to graduates of the University of Minnesota alone but to all graduates in their service. They indicate that qualities of leadership, resourcefulness, etc., should receive more attention. One writer states:

"Originality, inquisitiveness and resourcefulness are important attributes of a good engineer. Laboratory courses can stimulate the growth of these qualities only by forcing the student to think for himself. In an effort to compress a maximum number of experiments into a minimum period of time, far too many laboratory courses provide the student with detailed instructions, complete to the turning of a valve and the pressing of a button. Such courses may provide certain credits toward graduation, but contribute nothing to the education of an engineer."

Conclusions

There is quite complete agreement among all of those contacted that Heat Power Laboratory instruction can make the contributions mentioned in the questionnaire. There is also good evidence even though the number of people contacted is relatively small, that our students are not getting what they should out of laboratory instruction. Present laboratory methods are not contributing to originality, inquisitiveness, or resourcefulness. There is also little evidence that qualities of leadership are enhanced by the work done in these laboratories. Laboratory experiments are far too cut and dried to stimulate the imagination.

I like Professor Obert's plan (9) of gradually shifting the responsibility for conducting the experiment from the instructor to the student as they progress through the last year's work. There was a universal opinion among the graduates we contacted that the laboratory was important and the time given to it should be increased rather than decreased, but not for the purpose of adding routine or stereotyped work. The content of the laboratory course is by far less important than the development of active engineering minds.

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Analogs—Tools of Engineering

BY WALTER W. SOROKA

Associate Professor of Engineering Design, University of California, Berkeley

In recent years the use of analogs for the solution of engineering problems has been given widespread recognition in technical literature. One might ascribe the rapid growth of this development to the stimulus engendered by the difficult problems requiring immediate answers under stress of war. Government research bodies have been particularly active in sponsoring the development of analog methods and of associated equipment. As a result, much useful material is available for student instruction in the ways, means, and economical aspects of solving complex problems by means of analogs.

That this is an important field of knowledge to the engineer perhaps needs no further explanation. A course of study designed to take advantage of the developments in analog computing is discussed below.

Physical systems of concern to the engineer are usually characterized either by a continuous distribution of properties (e.g., temperature distributions in solids, velocity distributions in fluids, stress distributions in elastic plates, etc.), or by a discrete distribution (e.g., rigid masses interconnected with springs). This distinction in physical aspect leads to a distinction in the type of differential equation describing the behavior of the system. The continuous distribution leads to partial differential equations, while the discrete distribution leads to ordinary differential equations, or to sets of simultaneous ordinary differential equations. The methods employed by the engineer in solving his particular problems are conditioned at least in part on the type of equation encountered.

The solution of the governing equation may be accomplished in a number of ways. Perhaps the most ready method (and usually the most approximate) is to estimate an answer on the basis of past experience. This method has many advantages, if it can be applied, and so has a considerable following. Undoubtedly all engineers practice it at various times. Obviously, such a method is likely to be highly inappropriate for problems involving complex interrelations between variables. The engineer must then decide on a more precise approach. His decision would normally be based on a number of factors, some of the important ones being:

1. The expectancy of success.
2. Relative costs.
3. Length of time to arrive at a solution.
4. Dependability of the results obtained.

Often an analytical solution is the least costly and the most rapid. However, engineering problems frequently attain such complexity that an analytical solution is practically unattainable. If the problem is to be solved, some experimental aid must be used. This may involve a direct test. But direct experimentation may be too costly or otherwise physically impossible. In such cases an indirect approach by means of an analogy is likely to be the best recourse.

An analog is a device which obeys an equation identical in form with that governing the problem under consideration and which may be subjected to boundary, or initial, conditions of corresponding form. Results obtained by

operating the analog may then be converted to corresponding results for the actual problem and the desired solution so obtained.

Types of Equations in Engineering

In the domain of partial differential equations, the engineer is concerned to a large extent with equations of the following forms:

Laplace's equation,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0 \qquad (1)$$

Poisson's equation,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = f(x, y) \qquad (2)$$

Diffusion equation,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = \frac{1}{a^2}\frac{\partial\phi}{\partial t} \qquad (3)$$

Wave equation,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = \frac{1}{c^2}\frac{\partial^2\phi}{\partial t^2}. \qquad (4)$$

The ordinary differential equations of primary interest to the engineer are usually of the form:

$$\frac{d^2\phi}{dx^2} + c(x)\frac{d\phi}{dx} + F(\phi, x) = 0. \qquad (5)$$

These may occur singly or as sets of simultaneous equations with added coupling terms. Notably, Eq. (5) occurs in vibration problems wherein $c(x)$ is a constant representing viscous damping, and $F(\phi, x)$ is a function representing the spring restoring force ($k\phi$) and the externally-applied exciting force $F\cos\omega x$.

In addition, the engineer is also concerned with algebraic equations. These may occur as sets of simultaneous linear algebraic equations, or as single equations of high degree with complex roots and complex coefficients.

Except for a few relatively simple cases, analytical solutions do not exist for many of the problems falling into the above classifications. As a matter of fact, most engineers in industry are not expected to have a facility with analytical methods which will permit them to carry through a highly complex analysis. For this reason engineers rely heavily on direct experimentation. A better understanding of the analog approach should give the engineer added tools for more ready and rapid answers.

The Laplace Equation

Eq. (1) governs the distribution of stream function and of velocity potential in two-dimensional incompressible ideal flow, of pressure in two-dimensional incompressible viscous flow, of temperature in steady state heat conduction, of principal stress sum in plane stress problems, of general stress function in the torsion of prismatic bars. When irregular boundaries are involved such problems are difficult to solve analytically. Resorting to analogs, one finds that the vertical positions of points on the surface of a thin membrane or soap film stretched over a boundary of varying height are also governed by Eq. (1). Hence, the membrane may be used to solve the above problems experimentally by measuring the displacements of such a film. This method has been used to evaluate problems in torsion, principal stress distributions in photoelastic specimens, and potential distributions about electrodes.

The Laplace equation governs the voltage distribution in a thin electrically-conducting sheet. This sheet may be a solid, or it may be an electrolyte. If it is made geometrically similar to the physical field under investigation and if corresponding boundary voltages are applied around its edges, the voltage distribution through the interior of the sheet will be directly related to any of the sought-for functions. The conducting sheet will accomplish the same results as the membrane and do it perhaps with greater convenience. If a solid sheet is used, d-c voltages may be applied to the boundaries. If an electrolyte is used, a-c is required since d-c results in polarization and gas formation at the electrodes. Generally, the electrolyte is tap water.

If one does not require the precision of a continuous distribution of the function ϕ, Eq. (1) may be reduced to finite difference form and the solution accomplished either numerically or by means of an analogy. In finite difference form Eq. (1) is:

$$\frac{\phi_1 + \phi_2 + \phi_3 + \phi_4 - 4\phi_0}{h^2} = 0. \quad (6)$$

The values of ϕ are taken at discrete points represented by the intersections of a square network of spacing h drawn over the area comprising the problem. The values ϕ_1 through ϕ_4 are taken at the four nearest intersections surrounding the intersection point ϕ_0. Evidently, if the values of ϕ are so chosen over the entire area that Eq. (6) is satisfied, an approximate solution of the Laplace equation will have been attained, the degree of approximation depending upon the fineness of the net used. This solution may be accomplished by first guessing at a distribution of ϕ and then correcting this distribution as many times as is necessary to finally satisfy Eq. (6) at all points. Since boundary values of ϕ are true values to begin with, it is not difficult to see that the stationary values at these points will eventually bring about stationary values at all other points if the averaging process is repeated a sufficient number of times.

The above iteration procedure, modified by various methods for accelerating the rate of convergence (e.g., Southwell's relaxation methods), undoubtedly provides the most convenient and rapid means for solving an individual problem involving Eq. (1). If many problems are to be solved, there is a good possibility of saving much time and drudgery by using an electrical network analogy.

If one considers each of the sides of the squares formed in the numerical procedure to be replaced by an electrical resistor, and if voltages are impressed on that end of each resistor which intersects the boundary, in accordance with the boundary values of ϕ, then the voltages at all intersection points satisfy Eq. (6) and the numerical iteration is accomplished immediately and automatically by current flow through the network. At the boundaries, the network squares are not likely to be complete. Therefore, in constructing the resistance network, the resistance value is taken to be proportional to the length of line it replaces. Thus, throughout the interior of the network the resistors will be of equal magnitude; at the boundary, they will usually be of reduced magnitude.

It might be worthwhile to note that if one were to punch square holes in the continuous conducting sheet previously described, leaving only a narrow border between holes and leaving the boundary jagged, this sheet then becomes the resistance network just described. Evidently, an approximation is entailed by removing so much material. However, the approximation is tolerated because the network may be used to solve countless problems involving various shapes of areas merely by changing plugging connections without cutting out a complete new specimen for each problem.

The Poisson Equation

Eq. (2) is enough similar to Eq. (1) to allow the same methods to be used with some modification to account for the added term on the right hand side. Eq. (2) applies to incompressible flow problems and heat transfer problems where there are sources or sinks in the area under consideration. It also applies to problems in the torsion of bars when the stress function is taken in a somewhat different form from that used in connection with Eq. (1). With some further modification to include variation of oil film thickness, Eq. (2) will govern the pressure distribution in a journal bearing under conditions of fluid film lubrication.

To solve Eq. (2), the membrane analogy may again be used. This time a slight air pressure is applied on one side of the membrane to represent the term $f(x, y)$. In view of the fact that it is not convenient to vary the pressure from point to point over the membrane, this

analogy is restricted to problems in which $f(x, y)$ is a constant. Such is the case for the problem of torsion of uniform bars.

The electrically conducting sheets do not have this limitation, but are subject to a somewhat different type of limitation. The term $f(x, y)$ in this case is represented by means of a current distribution fed into the surface of the sheet. It is not practicable to supply such a current distribution over the entire area of the sheet. Instead, current electrodes may be placed at various discrete points on the sheet and sufficient current supplied to each electrode to make the total supplied equal to $f(x, y)$ integrated over the area of the sheet. The more electrodes one uses the more accurate the results will be. However, it is not necessary to use a forest of electrodes. One current electrode should suffice. Because of the linearity of Eq. (2), a complete solution may be obtained by the method of superposition, i.e., by adding partial solutions. A partial solution is obtained for each position of the current electrode. Thus, the single electrode may be moved from point to point and the solutions so obtained added to give the final solution.

A recent development at the University of Michigan is the fluid-mapping technique for solving the Poisson equation. In this case sources or sinks corresponding to the function $f(x, y)$ are used in a fluid flow field. For example, to solve the special Poisson equation for torsion, a frame geometrically similar to the cross section of the bar is filled with small grains of metal or sand. A glass plate is held slightly above the sand bed, allowing a very thin passage (about one-sixteenth of an inch in thickness) for fluid flow. Water is allowed to ooze up through the sandbed and flow out between the glass plate and the sandbox. Grains of dye on the glass plate leave colored streaks in the water marking out the streamlines of flow. The solution to the Poisson equation is obtained by drawing in the orthogonal lines on a photograph of the dye streaks.

An older hydrodynamic analogy solves the Poisson equation for torsion more directly. A container as above is filled with water (without sand grains) and the water surface sprinkled with aluminum powder. The container is then rotated. Using a camera attached to the tank, a photograph taken within a few degrees of the start of rotation (before vortices have time to form) gives a pattern of lines comprising a solution of the Poisson equation.

The finite difference equation corresponding to Eq. (2) is

$$\frac{\phi_1 + \phi_2 + \phi_3 + \phi_4 - 4\phi_0}{h^2} = f(x, y). \quad (7)$$

Since $f(x, y)$ is known at all points in the area of interest, Eq. (7) may be used in an analogous manner to that employed for Eq. (6) and a numerical solution thereby obtained.

The resistance network is also set up in the same manner as for Eq. (6). However, in this case a current of magnitude proportional to $f(x, y)$ is fed into each node. At nodes involving reduced resistance elements (i.e., near curved boundaries), the current is adjusted in accordance with the modified finite difference equation applying to such points.

The Diffusion and Wave Equations

Eq. (3) involves storage, e.g., of heat or of fluid. It is the equation for a transient process, so that the membrane analogy does not apply. The same electrical analogies may be used in this case as were used for the Laplace equation. Additional elements are required to provide an electrical charge storage corresponding to the storage of heat or mass. The resistance network is most conveniently used in this case and condensers are connected between each node and the reference potential corresponding to the initial condition for the particular

problem under study. Again, numerical methods may be used.

Eq. (4) is solvable by an electrical network when it is converted to finite difference form. Inductances and capacitances are required instead of resistances. Space does not permit a detailed discussion of this analogy, except to point out its existence.

Ordinary Differential Equations

Considering, now, the one-dimensional problems involving discrete masses on springs, the mass-inductance and mass-capacitance analogies for such systems are considered in all recent textbooks on vibration theory. Here, the differential equation for either current flow in a series circuit or voltage drop across a parallel circuit consisting of inductance, capacitance, resistance and power source corresponds to the differential equation for the velocity of a system consisting of mass, spring, dashpot and exciting force. Little more need be said about this analogy. When many masses are coupled together and the system is subjected to a system of forces, such as those produced by impact, the analytical solution becomes laborious. An electrical model then provides a convenient means for analysis. Parameters are conveniently changed, permitting the study of a wide variety of conditions without any changes in the setup other than turning dials or throwing switches.

In the event that variable coefficients and nonlinear terms appear in the equation of motion (as is the case in Eq. (5)), the direct analogy described above is not readily applied. Another method which is very useful for this case was developed at Princeton University. It parallels the procedure indicated earlier for the electrical network solution of Poisson's equation. The method consists of converting Eq. (5) into finite difference form, and then developing an electrical network in which the voltages at the various nodes correspond to the values of ϕ in the finite difference equation. The finite difference equation corresponding to Eq. (5) is

$$(\phi_1 - \phi_0)\left[\frac{1}{h^2} + \frac{c(x)}{2h}\right] + (\phi_2 - \phi_0)\left[\frac{1}{h^2} - \frac{c(x)}{2h}\right] + F(\phi_0, x) = 0. \quad (8)$$

If one considers a series circuit consisting of lumped admittances with a current I entering each node of the network, the equation relating the voltage of a given node, v_0, with the voltage v_1 at the node to the right and the voltage v_2 at the node to the left of the given node, is

$$(v_1 - v_0)Y_{0,1} + (v_2 - v_0)Y_{0,2} + I_0 = 0. \quad (9)$$

Thus, by setting up such an electrical circuit, the exciting forces and nonlinear spring forces may be included by an adjustment of the current I_0 at each node. The admittances of the network links correspond with the factors of $(\phi_1 - \phi_0)$ and $(\phi_2 - \phi_0)$ in Eq. (8). It should be pointed out that these admittances are derived on the basis of current flow toward point 0 from points 1 and 2. Should current flow in the reverse direction at any time, the admittance of the link must change. This may be accomplished by means of a series admittance and isolating amplifier placed in parallel with the normal admittance. However, the admittances may be made bilateral if each admittance is multiplied by a factor which varies from node to node. Since the magnitude of this factor is known at each node, it may be accounted for in converting the modified answers back to the desired answers.

Analogs for Structural Analysis

Electrical networks may be used also to solve the equations of equilibrium of structures. Developed by Bush of M.I.T. early in the 1930's, the analogy is between Kirchhoff's law for currents at a

node and the equation of equilibrium of forces at a point. Since in a three-dimensional structure there are three sets of equations of equilibrium, the electrical analog of a structure will consist of three separate electrical circuits coupled to each other through transformers representing the diagonal members of the structure.

To evaluate stresses in continuous elastic media, McHenry of the United States Bureau of Reclamation developed a lattice analogy wherein each small element of the continuum is replaced by a pinned lattice frame consisting of four bounding members and two diagonals. An application of the electrical analogy of Bush to the lattice analogy of McHenry leads to a general electrical analogy for stress distribution in continuous elastic media. Such electrical analogies have been developed by Kron in recent years.

Differential Analyzers

The mechanical differential analyzer is an analog computing machine in which the differential equation of shaft rotations is the same as the differential equation to be solved. Few engineers appear to be acquainted with the principles of operation of this machine and how it may be used to solve their problems. Such machines are available at computing centers to industry to handle new problems. A course in analog computing methods certainly should include a good basic discussion of the mechanical differential analyzer. Much information has been published on the mechanical differential analyzer since its successful development some twenty years ago.

A more recent development is the electronic differential analyzer, or "Electronic analog computer." This is a unit in which voltages replace shaft rotations in the analogy between the differential equation and the machine performance. The machine is a compact unit occupying relatively little space and coming more nearly within the budget of moderate size industrial firms than the mechanical differential analyzer. Moreover, the setting up of problems requires primarily the setting of dials rather than the changing of gears, so that setup time is greatly reduced. Since electrical current flow rather than shaft rotation is the motivating influence, solutions are capable of being run off with a considerably greater speed.

The differential analyzers have an important advantage over other types of analog computers in that they are not restricted to particular types of equations but may be used to solve virtually any equation, linear or nonlinear, which does not exceed the capacity of the machine.

Algebraic Equations

The numerical solution of large sets of linear simultaneous algebraic equations is another field in which the drudgery and time required for a solution may be mitigated. Such a set of equations may be solved numerically by assuming a solution first and then correcting a root in each equation successively so that each equation is satisfied in turn. Of course, upon going to the second equation, the first equation is thrown out of balance by changes in the second root. After all equations have been traversed once, only the final equation is satisfied by the first improvement cycle. The cycle is then repeated as many times as necessary to arrive at stationary roots.

A commercial machine which performs exactly this process by means of an electrical analogy was developed by the Consolidated Engineering Corp. The process involves the multiplication of pairs of numbers and their algebraic addition. This is accomplished with voltages by means of potentiometers and summing resistors. In the solving process the potentiometers representing the roots are adjusted in succession to a null for each equation in turn, one root potentiometer being used only with one equation. The nulling process is re-

peated as many times as necessary so that finally in switching from equation to equation there is no indication of unbalance. The readings of the root potentiometers are then the desired answers.

The Mallock machine invented in Great Britain in the early 1930's uses transformers for multiplying and for adding the products. The result is a direct solution of the simultaneous equations without the necessity of successive approximation.

Considerable work has also been done in setting up electrical analogies for the solution of high degree algebraic equations. A number of machines of different types have been developed to accomplish this purpose. In all machines the basic procedure appears to be the transformation of the roots to trigonometric form, and then the development of sine and cosine generators and harmonic synthesizers. For example, the equation

$$a_n x^n + a_{n-1} x^{n-1} + \cdots + a_0 = 0 \quad (10)$$

is transformed to

$$\sum_{m=1}^{n} a_m r^m \cos m\theta + i \sum_{m=1}^{n} a_m r^m \sin m\theta = - a_0. \quad (11)$$

The sines and cosines are generated by mechanical means as in the Bell Telephone Laboratories "Isograph" and the University of Texas machine, or by electro-mechanical means as in the University of Pennsylvania and Radio Corporation of America machines. By appropriate couplings between units all the necessary multiples of θ are generated. The coefficients $a_m r^m$ are set on slider-cranks or on potentiometers as the case may be. The outputs of the harmonic generators, multiplied by the appropriate coefficients, are added by linkages or by electrical means. In operation, the angle θ and the setting of $a_m r^m$ are adjusted by successive approximations until Eq. (11) is satisfied. As many such settings will be found as there are roots to the equation.

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The Place of Tool Engineering in an Industrial Engineering Curriculum[1]

By CLARENCE E. BULLINGER

Head of Department of Industrial Engineering, Pennsylvania State College

To discuss this topic is to discuss the development of the curriculum in Industrial Engineering from the time of its inception until the present time. The curriculum was established in 1908.

The field of Industrial Engineering as envisaged at Penn State at the present time divides the work or interest into four fields:

1. Methods: Tool engineering, motion and time study, factory planning.
2. Cost Control: Engineering economy, cost accounting, budgetary control, and standard costs.
3. Personnel: Psychology, personnel administration, and leadership.
4. Coordination: Industrial organization and administration, and scientific management.

The field of Industrial Engineering at the time of its inception was practically the same as now. There were, however, different emphases on the several parts of the program. Industrial Engineering was then breaking away from Mechanical Engineering to which it was closely tied. Therefore, the emphasis was still very great on subjects within that area. For example, machine design was requirement and included kinematics, machine elements and machine design practicum. It also included a course on the design of steel mill buildings. The bulk of instruction in what might be called tool engineering was on machine tool processes and chiefly from the standpoint of machine operation.

As the curriculum developed there was a tendency to emphasize then over-emphasize and finally to deflate the amount of time given to the subject. It was the familiar problem of finding the proper balance. In 1924, a course in tool design of one credit appeared in the catalog as a requirement together with a Senior elective of three credits. This was in addition to a basic course in machine tool operation of one credit and an advanced course in machine tool operation of two credits. In 1933–34 the three credit elective course was dropped as indicating over-emphasis and the value of the required tool design course was increased to three credits along with the dropping of the advanced machine tool course. All this time the courses in machine design were also taken.

In about 1936–37, a general review of the curriculum was made. The department staff believed that the developments in methods, motion study and time study, as well as production control, warranted more time. Accordingly the machine design courses were dropped and the credits formerly assigned to them were re-distributed to courses in methods, operation analysis, production control and tool design. The resulting tool design course was assigned four credits. The prerequisites for this course are courses in freshman drawing and machine shop production.

Place of Tool Engineering

You will notice that tool engineering is assigned to that section of subject matter

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called "Methods." We believe that the Industrial Engineer must be a master of "Methods." He cannot do his work as an operations analyst, motion study or time study analyst completely and satisfactorily unless he also knows something about the processes of manufacture with which he deals. Since the modern concept of time study is to standardize the setups first before determining times, it becomes essential for the Industrial Engineer to know something about how the manufacturing process operates and be able to point out how it can be improved. He must know the basic operations, but also something about the design of accessories to the manufacturing operation. While he may never have to design the accessories in detail himself, still he must be able to recognize where improvements in the operation can be made through the design or re-design of the essential accessories. At any rate he must be able to talk the language of the expert and highly specialized tool engineer.

It is impossible in a college curriculum to give the student of engineering a complete background of manufacturing processes in any given field of manufacture. Engineering schools have, therefore, given work in basic machine tools and basic manufacturing processes such as forging, heat-treating, welding, foundry and machine tool operation. Since it is difficult to develop in the short time available a mastery of the field of manufacture extending out of the basic processes into the field of mass production and interchangeable manufacture, it becomes necessary to introduce the student of Industrial Engineering to the technique of going from basic manufacturing operations to mass production operations.

Our present course is called: I. E. 328 —Tool design—four credits—practicum eight (8) hours per week with outside preparation. Principles of tooling for mass production and interchangeability in a machine shop; the transition of basic, general purpose machine tools to special, single purpose tools; operation analysis; tool layout; and design of jigs, fixtures, and other special tools. The prerequisites are courses in drawing and machine shop. The credit value allows for eight hours in the drawing room and four hours of outside work.

Its place in the curriculum is in the second semester of the Junior year. At that time the student has completed his course in physics, mechanics and strength of materials including a course in the properties of materials and the testing of materials. It is concurrent with a course in production control and motion and time study and precedes the course in factory planning and layout.

Objectives and Course Content

The primary objective of the course is to acquaint the student with the principles and tools employed in mass production. Although the course is based on machine shop practices, it should be noted that the same methods with variations are applicable in other manufacturing industries.

Secondary objectives are to develop some ability in job or operation analysis; the selection of machine tools and cutting tools for performing operations; tool layout; and the design of simple jigs, fixtures, and other tools.

This course is not a drawing course. Lectures and recitations, based on the text and other sources, are coordinated with practicum in so far as possible. Written reports are sometimes required. Instruction includes demonstrations on quantity production tools in the shop laboratories. Sketching, and the use of templets are employed to reduce instrument drawing to a minimum. Students are required to follow standard drafting practices. Some instrument drawing will be required, notably in the cam design problem for automatic screw machines, and in the design of certain tools.

In general, the work is of a creative nature. A problem is presented for solution. Very little if any copying work

is involved. The student must analyze his problem, determine the principles involved, examine industrial practice and come up with a solution in the light of all of the factors in the problem.

Some idea of the coverage and method of attack will be seen from the following itemized statement of the several assignments:

Period 1. Organization.
A presentation to the student of the objectives of the course together with the methods of operation, requirements, tools, text books, etc., and what is expected of the student.

Period 2. Lecture and recitation. Definitions.
Tool definition, definition of tool design or tool engineering, economic factors in tooling, relationships between:

1. Technical design
2. Manufacturing design
3. Tool design

Operation sheets. The tool designer's task and his professional requirements.

Period 3. Lecture and recitation. Turret lathes.
Classification, elements, types of jobs such as chucking, bar, small to moderate lots or quantities, tooling principles, speeds and feeds, tool templets.

Periods 4–10. Lecture, demonstration and practicum. Turret lathe—chucking type.
Examples of chucking problems, chucks and power operated holding devices, chuck jaws, special fixtures and steadyrests, universal chucking equipment, turret lathe tools and other catalogs.

The practicum part consists of problems in which the student is required to list the operations, make tool layout and prepare production sketches which show the sequence of the operations.

Periods 11–14. Lecture, demonstration and practicum. Turret lathe—bar type.
Examples of bar chucking problems, collets and arbors, universal bar equipment, turret lathe tools.

The practicum part is similar to periods 4–10.

Periods 15–24. Lecture, demonstration and practicum. Automatic screw machine.
Construction and use of automatic screw machines. Demonstration of Cleveland and Brown & Sharpe machines and in particular cam arrangements.

The practicum part consists of problems in which the student is required to make operation sheets, tool layouts, and make all calculations needed in the design of a set of cams, as well as drawing.

Periods 25–30. Lecture, recitation and demonstration and practicum.
Dies.
Die definition, classification of dies, details of progressive dies, piercing, blanking dies, details of die components, presswork materials, blanks, subpress and die set.

The practicum part requires the student to make an assembly sketch of a die. Detail sketches are made for all parts.

Period 31. Lecture and recitation. Welding.
Welding, pressure and non-pressure processes, brazing, flame processing, arc and gas welded joints.

Period 32. Lecture and recitation. Jigs.
Jig definition, economic factors in use of jigs, classification of jigs, plate, angle plate, shaft, leaf, box indexing, cam, swinging clamp, vise, standardized jigs, built-up jigs, pinned and screwed construction and welded construction.

Period 33. Lecture and recitation. Detail of jigs.
Details of jigs, clamps, quick acting screws, cams, hook clamps, wedge clamps, quarter turn screws, rack and pinion clamps, toggel clamps, spherical washers, rest buttons, jacks, leafs, hinges and pins, handles and knobs, U-lugs, jigs bushings and jig feet.

Period 34. Lecture and recitation. Jig and fixture design.
The principles of jig and fixture design plus the planning of the jig design.

Periods 35–36. Lecture and practicum. Plate jig.
Make an assembly sketch of plate, jig, identify parts and prepare bill of material.

Periods 37–39. Lecture and practicum.
Angle plate jig.
Similar to 35–36.

Periods 40–43. Lecture and practicum.
V-block or shaft jigs.
Similar to 35–36.

Periods 44–53. Lecture and practicum.
Leaf or box jig.
Make an assembly sketch. Body may be cast or built-up. Indicate how connected if built-up. Make detail part sketches and identify parts and prepare bill of material.

Periods 54–58. Lecture, recitation, demonstration and practicum. Fixtures.
Define fixture, classify types of fixtures, standard chucks, vises, dividing heads, milling, boring, broaching, tapping, turret lathe, grinding, planning, inspection fixtures. Fixture details and principles of design.

The practicum work consists of making an assembly sketch of a fixture and identification of all parts on a bill of material.

NOTE: The periods are of two hours' duration and are held in a drafting room in which are located catalog files of machine tools and demonstration jogs and fixtures. The major amount of class room work is scheming or planning the design. Cross-section paper in ⅛″ squares is used as a foundation for tracing paper on which work is done. The cross-section paper is also used for final sketching and even drawings.

Visualization of Fundamental Principles in Elasticity Using Rubber Models

By A. J. DURELLI, C. H. TSAO and R. H. JACOBSON

Armour Research Foundation

The understanding of the fundamentals of the theory of elasticity and of strength of materials became easier when experimental methods (photoelasticity, in particular) allowed the visualization of some stress distribution phenomena. The neutral axis and the linear distribution of stresses across a beam under pure bending, for instance, were no longer assumptions or results of abstract calculations, but things that could be seen.

There is an old experimental stress analysis method, however, which does not seem to be commonly used to the full extent of its possibilities, namely, the rubber model method. Some books show the photograph of a rubber sheet with a circular hole. However, the only conclusion of the test seems to be that the circular hole becomes elliptical upon deformation.

A course on experimental stress analysis was organized last semester at the Illinois Institute of Technology and the rubber model method was found very convenient to help in the understanding of some fundamental principles such as the lateral contraction under pure tension (Poisson's effect), the values and directions of the principal stresses and the general translation of strains into stresses.

Equipment

The equipment necessary for the test is simple and inexpensive. For two dimensional tests, only a rubber sheet, a photographic camera and a microscope-micrometer are required. On the rubber sheet, a fine grid is drawn with India ink. The coordinate system may be polar or Cartesian and the distance between lines, which should be as thin and well defined as possible, may vary from 1/32 inch to 1/2 inch.

The distribution of stresses around a circular hole in a plate under a unidimensional state of load is known since Kirsch found the formulae giving the stresses at any point of the field. The rubber model method seems well adapted to experimentally check these formulae.

A sheet of compounded rubber about 36 inches in length, 12 inches in width and 1/4 inch in thickness was used. A circular hole 1 inch in diameter was drilled in its center and a constant deformation was applied to the sheet by using a turnbuckle. To avoid friction, the sheet was supported on ball bearings, as shown in Fig. 1.

Photographs of the sheet were taken for zero load and for increasing amounts of deformation. Figures 2 and 3 show photographs of the grid at zero load and at 10% total deformation, approximately.

The Visualization of Some Fundamental Principles

The first obvious feature of the photographs is that the drawn circles become ellipses after deformation. The circle on the longitudinal axis of the sheet elongates longitudinally and contracts transversally. With the micrometer, it is easy to measure the length of the axis before and after deformation. Referring the change in length to the original length, the principal strains are obtained. The ratio between them is Poisson's ratio.

It is also obvious that although the di-

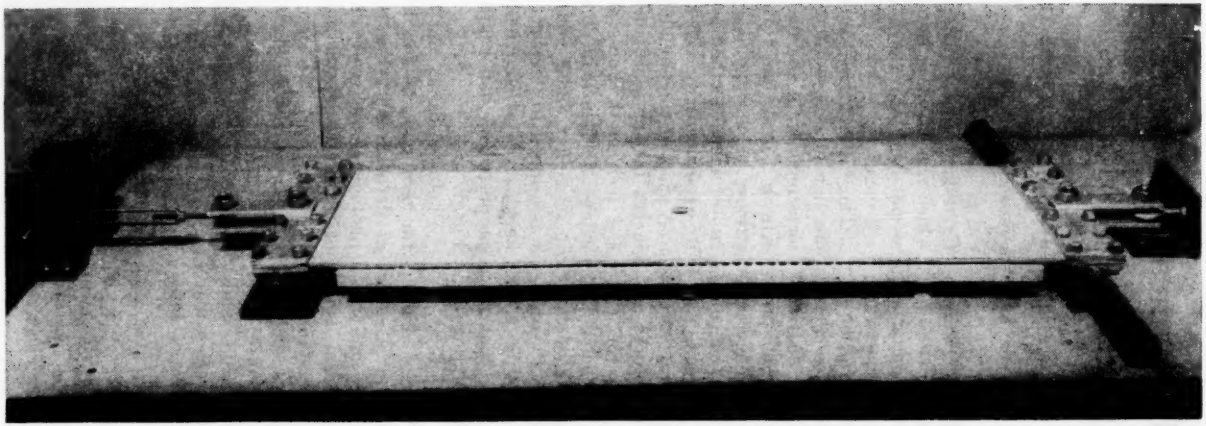


FIG. 1. Test setup.

A rubber sheet approximately 36 by 12 by ¼ in. with a 1-in. hole is stretched in its plane. The grid is drawn with India ink. The sheet rests on ball bearings to decrease friction.

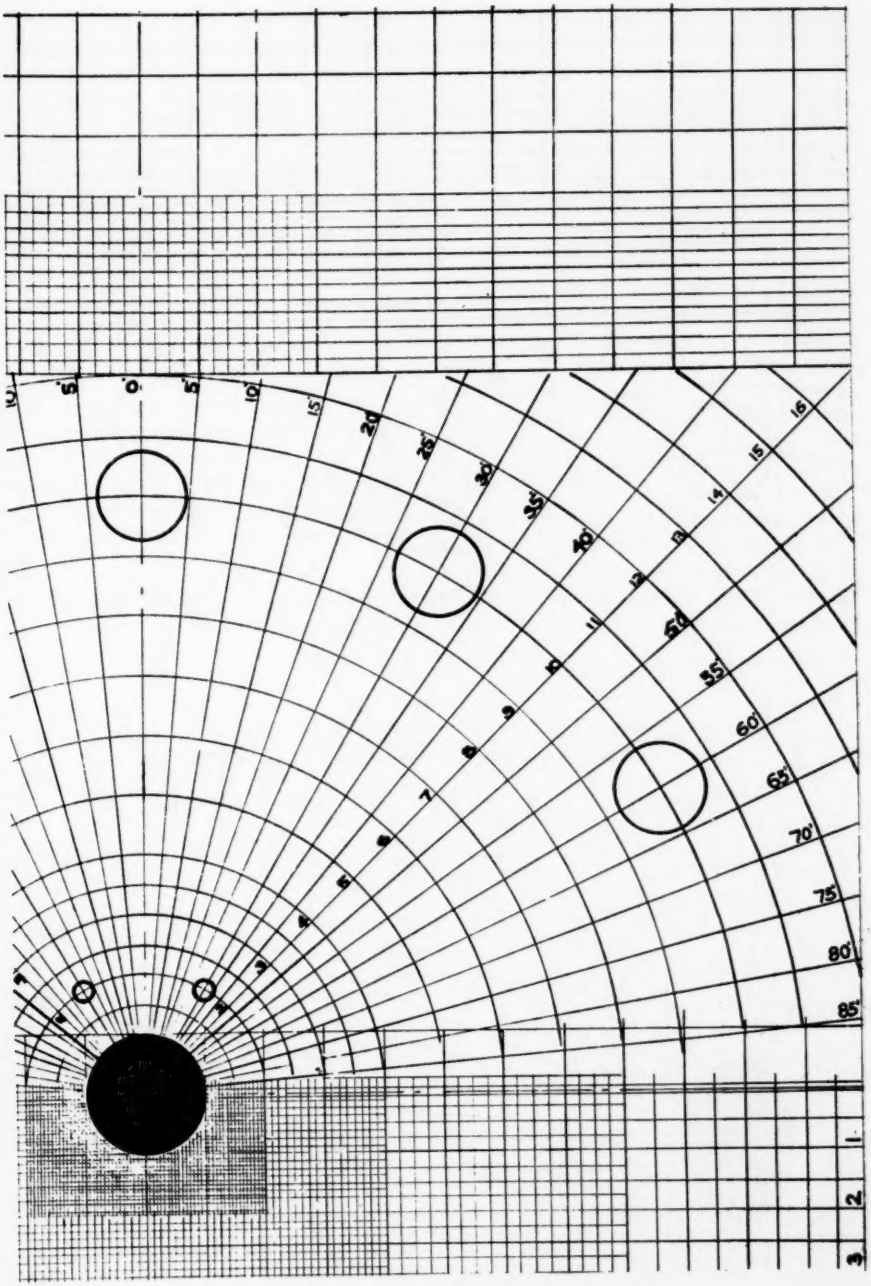


FIG. 2. Rubber sheet under zero load.

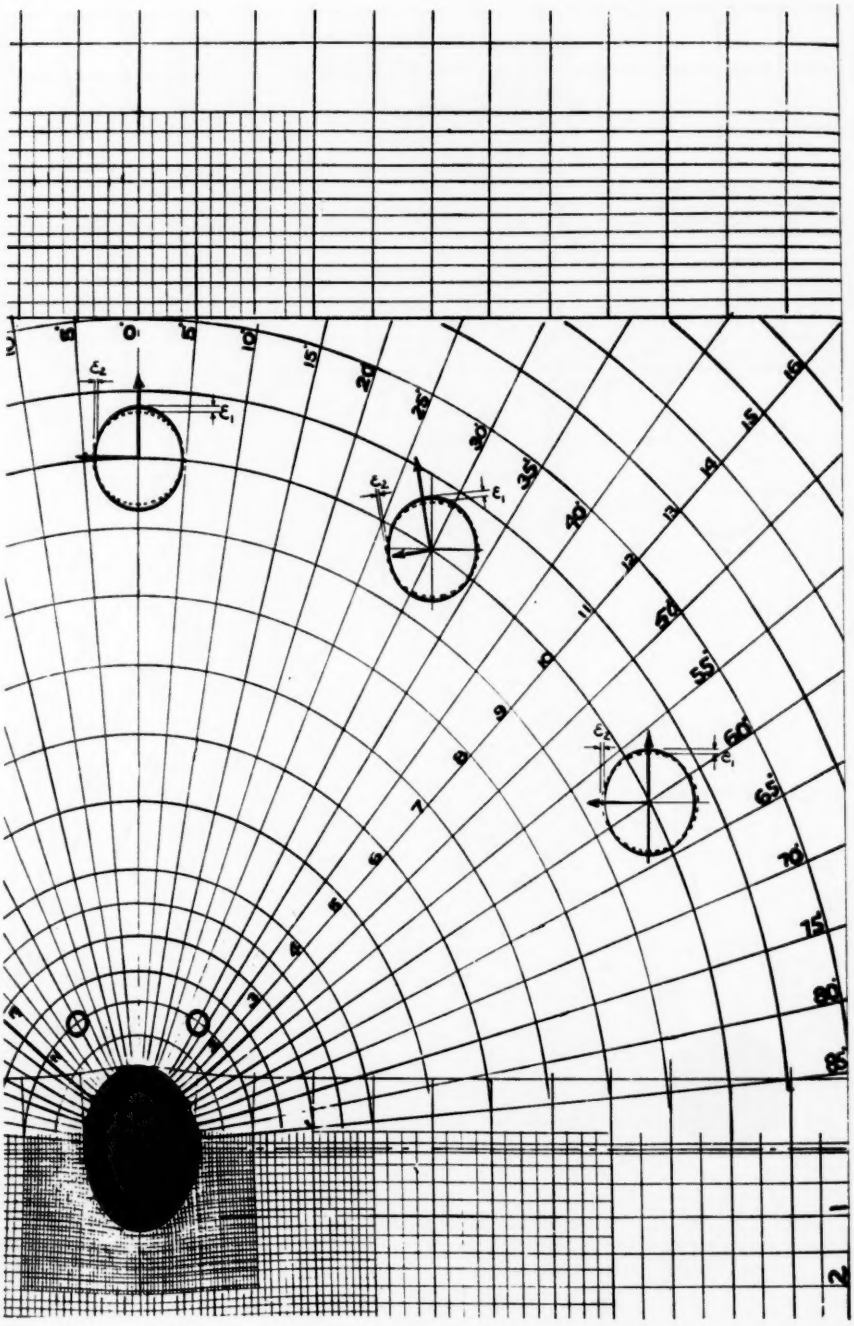


FIG. 3. Rubber sheet under about 10% elongation.

rections of the axes of the ellipse on the longitudinal axis of the plate are vertical and horizontal, the axis of the other ellipses shifted. The direction of these axes is the direction of the principal strains and stresses.

Superimposing the original circle on the ellipse, produced by the deformation, as shown in Fig. 3, the strains in all directions become apparent. These strains are proportional to the distance between the circle and ellipse. (The circles should be small for this to be true.)

The hole becomes elliptical, its axes coincide with the axis of the plate. In the polar coordinate system radial lines diverge prominently near the boundary, close to the transversal axis, and converge close to the longitudinal axis, making the understanding of two fundamental facts produced by the discontinuity easy:

A. There is an extra elongation at the boundary on the transversal axis (stress concentration phenomenon); and
B. There is a contraction at the boundary on the longitudinal axis. Since at free boundaries the state of stress is unidimensional, this contraction demonstrates the existence of the compressive stress.

Checks with Theory

The micrometer measurements of strains can be plotted along a selected line. The transversal axis seems to be particularly suited for this purpose. Transversal and longitudinal strains can be plotted, these values translated into stresses using the fundamental formula relating strains and stresses and, finally, the value of the stresses can be compared with those given by Kirsch. The ratio between the diameter of the hole and the width of the plate was 1:12 in the I.I.T. test and the check with the theory was found to be good in spite of

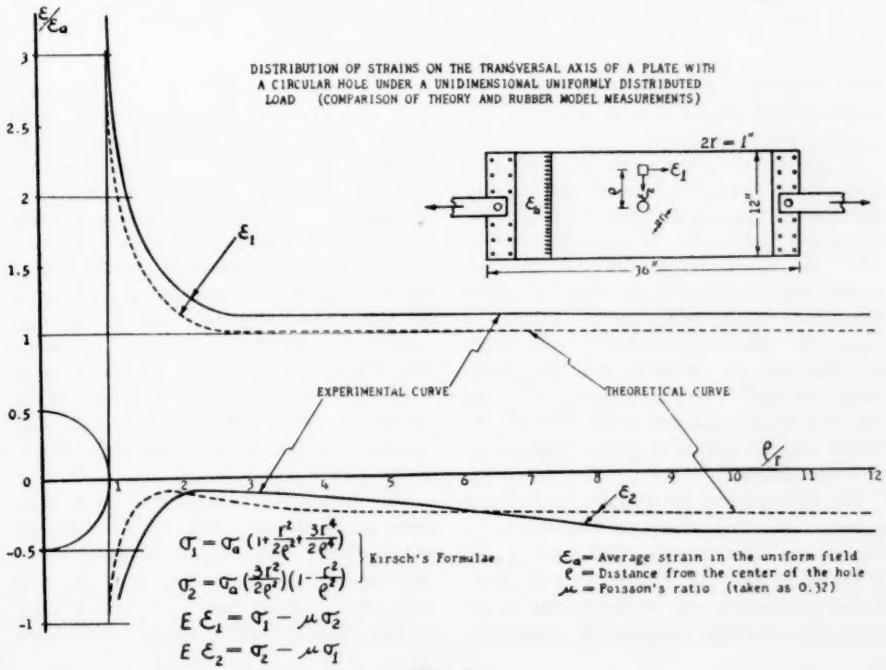
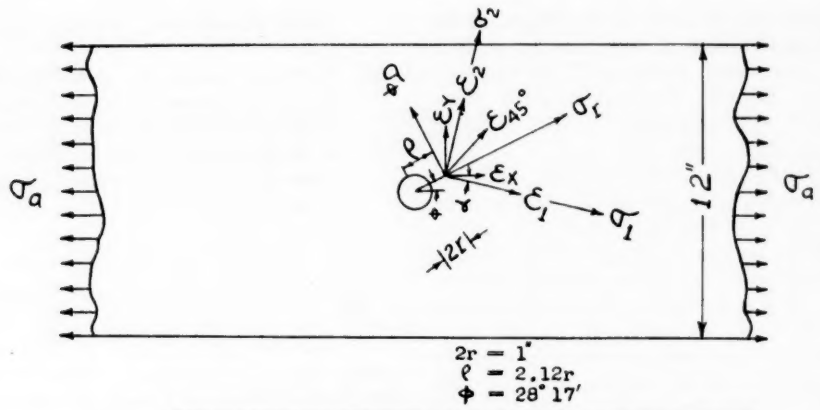

DISTRIBUTION OF STRAINS ON THE TRANSVERSAL AXIS OF A PLATE WITH A CIRCULAR HOLE UNDER A UNIDIMENSIONAL UNIFORMLY DISTRIBUTED LOAD (COMPARISON OF THEORY AND RUBBER MODEL MEASUREMENTS)
2r = 1"
12"
36"
EXPERIMENTAL CURVE
THEORETICAL CURVE
Kirsch's Formulae
ε_a = Average strain in the uniform field
ρ = Distance from the center of the hole
μ = Poisson's ratio (taken as 0.32)

FIG. 4.



	Theoretical value	Experimental value
σ_1	$0.924\,\sigma_a$	$0.938\,\sigma_a$
σ_2	$-0.168\,\sigma_a$	$-0.190\,\sigma_a$
λ	12° 20′	13° 10′

To calculate the theoretical values of stresses Kirsch's formulae and the formulae translating normal and shear stresses into principal stresses were used. To calculate the experimental values of stresses rosette formulae and formulae translating strains into stresses were used. (μ = Poisson's ratio was taken as 0.32.)

FIG. 5. Theoretical and experimental determination of stress and strain at any point on a plate with a circular hole, under unidimensional uniformly distributed load.

some discrepancies. Figure 4 shows the experimental results for strains and the comparison with theory.

A point ($\rho = 2.12r$; $\phi = 28°\ 17'$) was selected to determine the stresses using the rosette formulae. Three strains were measured (vertically, horizontally and at 45°) and the principal stresses and their angles were calculated (see Fig. 5). Here also, the check with values calculated using the theoretical formula was good. For this type of measurements, the photographs should be taken on plates, to avoid film shrinkage, and the readings made directly on the negative plates instead of positive prints.

No attempt has been made to find the reason for the discrepancies between theory and the experimental results. It is possible that the Poisson's ratio used is not the correct one, or that creep in the material somewhat changes the stress distribution. Before the method can be used as a regular stress analysis method, these points should be thoroughly investigated. However, it is believed that as a teaching tool the method's accuracy is adequate. It should be remembered that in a plate similar to the rubber plate used, but made of structural steel, the transversal strains on the transversal axis are of the order of 100 microinches per inch if the material is not allowed to yield at any point. The total contraction on a 0.25 in. base length is 25 microinches. Very few strain gages can read deformations of this amount with an error of less than 20 per cent.

One important assumption underlines these tests, namely that rubber behavior has a linear relationship between stress and strain. It was found, however, that with the rubber used (Hevea natural rubber 28.5%, fillers 57.3%, vulcanizer

8.6%, sulphur 3.1%, oils 3.5%) that relationship could be considered straight for all practical stress analysis purposes if the strain is not larger than 10 per cent. It is not necessary, however, to determine the modulus of elasticity of the rubber used. All strain measurements may be referred to the strain at the uniformly stressed part of the sheet (away from the hole) as a unit. All stress results become this way dimensionless, and besides that any creep effect is minimized.

The method also has possibilities, not yet fully developed, as a regular stress analysis method and may be the best suited to the study of the distribution of stresses around elliptical holes. The accuracy is fairly good if the deformations are not too large and if a microscope-micrometer is used for the measurements.

Conclusions

The rubber model method seems to be a very useful tool in demonstrating some phases of theory of elasticity. The following facts become obvious:

1. Poisson's effect.
2. Strains at a point, in all directions.
3. Direction and magnitude of principal strains.
4. Sign of stresses at the boundary of a hole.

The following checks with theory can easily be obtained:

1. Stress concentration produced by a hole.
2. Distribution of stresses around a discontinuity.
3. Stresses at a point calculated from three strain readings.

Teaching Field Theory to Undergraduate Electrical Engineers

By L. V. BEWLEY

Head of Department of Electrical Engineering, Lehigh University

Many teachers of engineering have had cause for concern over the lack of coordination and the waste effort involved in the teaching of mathematics to engineering students. The chief trouble seems to be that the formal courses in mathematics are completed with differential equations, or advanced calculus, by the end of the first semester of the junior year; and long before effective use is made of these mathematical disciplines in engineering courses. The time delay is often fatal. The usual courses in physics, mechanics, strength of materials, hydraulics, thermodynamics, d-c machines, and other engineering subjects through the junior year rarely do more with mathematics than very simple differentiations and integrations. Fourier series and the barest possible use of differential equations may appear in introductory courses on a-c circuits and machines, but there is certainly nothing intense about the mathematical impact before the senior year.

However, in his senior year the student finds himself confronted with the necessity for making full use of his long dormant mathematical training. At that stage random applications of differential equations are to be found in such courses as transmission lines (the long line equation, the catenary, and perhaps skin effect), wire communication, a-c machinery (electro-mechanical oscillations), or electronics (simple transients). One finds also spasmodic applications of Fourier series in such courses as a-c machinery (armature reaction, permeance, and flux distribution, and induced voltages). Courses in symmetrical components, system stability, and radio, while of high analytical content, do not draw extensively on the student's previous mathematical training. Even courses on advanced machine theory, or servomechanisms, or theory of networks, in spite of any dependence on determinants, matrices, Fourier analysis, algebraic theorems, differential equations, and operational calculus; do not exploit fully undergraduate mathematics.

Courses Utilizing Higher Mathematics

There are, however, certain courses which bring into play on genuine engineering problems the whole galaxy of undergraduate mathematics, and in addition point the way to the necessity for advanced study in mathematics as a necessary engineering tool. They may well be called "dual-purpose" courses, in that they serve not only a well-defined engineering need, but also provide a powerful review and extension of mathematical disciplines.

The almost universally adopted undergraduate courses in transients, based on either Heaviside's or the Laplace transform methods, require a substantial background in the theory of differential equations, gamma, error, and Bessel functions, certain theorems in algebra, Fourier series and integrals, and determinants; and such courses are excellent not only as a means of consolidating the student's previous mathematical experience, but also in directing his attention towards advanced study.

A course on transmission line surges, to include the analysis of the traveling waves initiated by lightning and switching, and the resulting transients in the windings of machines, is an excellent vehicle for demonstrating the practical application of ordinary and partial differential equations, operational calculus, series, boundary value problems, step-by-step methods, Bessel functions, and other mathematical aspects.

A course in electromagnetic theory, to include Maxwell's equations and solutions for wave guides, is of great value in teaching the utility and practicability of vector analysis, partial differential equations, and boundary value problems.

Course in Electromagnetic Fields

But few subjects on engineering analysis at the undergraduate level can match a course in electric and magnetic fields, taught at the proper level, as a means of exploiting and extending undergraduate mathematics to the full. Such a course, embracing numerous boundary value problems, is the dual-purpose course *par excellence*. For a number of years there has been such a course in electrical engineering at Lehigh called Electric and Magnetic Fields (EE 131), based essentially on two-dimensional field analysis. (See "Two-dimensional Fields in Electrical Engineering" by L. V. Bewley, The Macmillan Co.)

The work starts out with a condensed review of complex numbers and simple functions of a complex variable, such as z^n, z^{-n}, log z, sin z, sinh z, log sin z, etc. The field plots corresponding to these elementary functions are assigned as class problems in order to acquaint the student with their patterns and various plotting techniques (interpolation, auxiliary curves, graphical superposition). The Cauchy-Riemann equations are then established, and it is shown how a system of curves orthogonal to those of a given function may be constructed, so that if the equipotentials are known in a particular problem the lines of force may be found, or conversely. As a by-product of the C-R equations, Laplace's equation is derived and illustrated by the solution for the temperature distribution in a rectangular bar whose faces are held at fixed temperatures. This problem illustrates the procedure in solving Laplace's equation in conformity with specified boundary conditions, and the use of Fourier expansions in either of two directions.

Various problems in fluid flow (parallel flow, vortex lines, source lines, source-sink flow, dipoles, and various combinations) are next investigated as further simple examples of the field plots of functions of a complex variable; but this time having rather specific physical significance. The extension of the same ideas to the electrostatic and magnetic fields of parallel and eccentric conductors of different sizes, of a simple vacuum tube, and of a string of vortices or a string of source-sinks, is then easily accomplished.

The detailed consideration of an infinite series of vortices (log sin z and log sinh z) offers an excellent opportunity to show the student how the general characteristics of a field can sometimes be found without actually plotting; by determining such things as the location of repetition points and stagnation points, local behavior in the vicinity of these points, and behavior at great distances. The student always gets a great kick out of seeing how the general pattern of a field can be sketched in after these things are determined from rather simple calculations. Incidentally, the field around the wires of a multiple-layer solenoid can be approximated by superimposing the fields of lines of vortices properly displaced.

Problems in the torsion of elastic prisms offer an interesting diversion involving Laplace's equation, boundary conditions, Fourier series, and the use of the C-R equations in determining orthogonal functions.

After the above preliminaries, it is possible to pass to the definitions and derivations (in two dimensions) of line and

surface integrals, Stokes' and Green's theorems, gradient, circulation, divergence, potential, stream function, and the concepts of irrotational and sourceless fields. These general equations are employed en masse thereafter. By means of them, Ampere's and Faraday's laws are expressed in curl form. At this point also the laws of magnetic flux refraction at an air-iron boundary are set up. The stage is then all set for specific applications to interesting boundary-value problems in engineering. Seven typical examples of this type have been selected, each demonstrating some new idea or procedure.

Applications to Boundary-Value Problems

The first example is a slot along one side of which there is a sinusoidal distribution of mmf. This problem demonstrates the use of Ampere's law in curl form, solution of the partial differential equation by product functions, selection of the integration constants to fulfill the boundary conditions, determination of the potential and stream line functions, plotting of the field, and finally the preparation of practical design curves for the permeance of an air gap with different modes of excitation.

The second example is Rogowski's celebrated analysis of the field and reactance of interleaved transformer coils. This problem demonstrates compartmentization into regions, specification of the current distribution by a Fourier series, regional solutions of the partial differential equation (Poisson type) of vector potential by product functions, determination of a large number of integration constants by the simultaneous solution of the equations of condition at the boundaries, plotting of the field, and finally the calculation of the flux linkages and reactances. This final operation introduces the use of the Fourier series of various functions for the purpose of evaluating certain infinite series, as well as the construction of rather involved Fourier series by repeated integration of more simple series. It is hard to find a better demonstration of many mathematical manipulations and principles towards an important engineering end than is contained in Rogowski's problem.

The third example is the determination by Roth's method of the field due to conductors in a slot. In this example, the partial differential equation is solved by a double Fourier series, the coefficients determined from the boundary conditions, and the field plotted. This is perhaps the first time that the undergraduate has encountered double Fourier series, at least in a very practical engineering problem.

The fourth example is the calculation of the eddy current loss of conductors in a slot. This problem demonstrates the setting up of a partial differential equation of current density from elementary principles, its reduction to an ordinary differential equation under steady state conditions, solution by hyperbolic functions, determination of integration constants, and calculation of the energy loss. Finally, various approximations based on the expansion and subsequent termination of infinite series, and also by ignoration of certain factors in the equations, are investigated and compared, and thus the student is introduced to some of the processes for justifying an approximation.

The fifth example is the calculation of the intersheet eddy current loss in laminated iron cores. This problem demonstrates the setting up and solution of a partial differential equation for a case in which the conductivity is different in orthogonal directions (thus corresponding to a crystalline medium). Here again product functions are employed, integration constants determined from boundary conditions, flux found by integration, losses calculated, and various approximations investigated in critical fashion. Infinite series solutions of two quite different forms are obtained in this problem, and their relative advantages explored, so that the student is shown how a conventional solution can sometimes be considerably improved (from

the point of view of simplicity, rapidity of convergence, symmetry, etc.) by a judicious procedure in the solution, or by an appropriate rearrangement of terms.

The seventh example is on skin effect in tubular conductors carrying alternating current. This problem in cylindrical boundaries demonstrates the setting up of the differential equation for the current density and its solution in terms of Bessel functions of the first and second kinds with complex arguments. In the accompanying numerical example the student gets a taste of Jahnke and Emde's Tables, and learns that he can not always rely on popular handbooks for necessary tables.

Other Subjects

The next general subject taken up is conformal mapping. After a few simple problems in unicursal curves, the bilinear transformation is introduced and the flow around plates and profiles investigated. This is followed by the Schwarz-Christoffel transformation, and its application to such problems as: the parallel plate condenser, the constricted conductor, a pipe bend, a field pole, conductors in an infinite slot, armature teeth and slots, Borda's mouthpiece, the simple orifice, angle bends, and plates. Each of these examples brings out something different in the manipulation of the Schwarzian transformation, and most of them are given a direct engineering significance culminating in design curves for fluxes or stresses.

The method of images offers an alternative method of calculating the field due to current filaments in a slot. The method is used for the determination of the field of eccentrically placed round conductors inside a sheath, and the sphere gap problem. Mathematically, the processes involved are important in showing how infinite series may be formed from physical considerations, and then summed.

The general theorems and analyses of the previous work are sufficient to establish rigorously the working rules for free hand flux plotting. An application of these rules to numerous situations, such as magnets, slots, field poles, etc., soon inspires confidence in the possibility of high accuracy by free hand flux plotting. Fields may be determined by this method, to whatever degree of accuracy demanded, which would defy mathematical attack. While the rules of procedure are very simple, and can be learned and applied readily, it must not be forgotten that they are founded on very involved general theorems and analysis, and there can be no real appreciation of these rules without a prior understanding of the mathematical foundation.

The final subject of this course on fields is an analysis of mechanical forces due to currents in magnetic fields. Ampere's rule is used to find the mechanical force on a current-carrying conductor in a slot, and the force between a pair of busbars. The derivation by the method of virtual displacement of the general force equations for saturated conditions involves either the differentiation of a definite integral whose limits and integrand are functions of the parameter with respect to which differentiation is performed, or the calculus of variations. The final numerical determination of the mechanical force necessitates a numerical solution of definite integrals. Thus problems in electro-mechanical forces can become very involved from a mathematical point of view.

It should be evident from the foregoing outline that a course in two-dimensional fields is almost ideal for the dual purpose of consolidating and extending the undergraduate's mathematical experience, and introducing him to engineering analysis of a high order. Furthermore, the course is of immense value as a review and application of the fundamental theorems of electricity and magnetism. And finally, it contains enough of the theory of functions of a complex variable to serve as a stepping stone to such additional theorems in that branch of mathematics as may be necessary for an adequate treatment of operational calculus and advanced network theory.

The Chemical Engineering Senior as a Freshman in the Heavy Chemical Industry[1]

By JOHN F. CROWTHER

Director, Eastern Research Division, Stauffer Chemical Company

I know of few professions which are bombarded so constantly with well-meaning advice from lay sources as the teaching profession. The fact that an organization of teachers should have invited further admonition on this occasion must be evidence of an exceptionally patient interest in self-improvement.

An appropriate interpretation of the title of this paper seems to require that I discuss two conjugate questions: firstly, what does the heavy chemical industry want from its newly graduated chemical engineers, and secondly, what is it actually getting? An answer to the second question is partly an answer to the first.

I do not need to tell you that every company wants its new men to be honest with property and with ideas, hardworking, and conscientious. Beyond this point, however, individual opinions and company policies begin to diverge fairly rapidly. I should therefore like to emphasize that all the opinions expressed by me this afternoon are equivalent in the aggregate to only one point on a plotting sheet. To get enough points for a good generalization, you will have to listen to a lot of other people.

Rating of Personal Traits

Although psychologists classify personal traits into many different categories, for the purposes of this discussion it is sufficient to lump them into two, which may be labelled "social" and "intellectual." Every company would like, if it could, to hire only men who rank at the top in both respects. Since there can never be enough honor graduates to go around, for the bulk of its needs industry must depend upon men who, *at this stage of their careers,* appear to be second or third grade in either social or intellectual qualities.

I have drawn up a little table indicating the percentages of graduates who, at the outset, are likely to prove really top-notch employees, (A) or are likely to prove unemployable, (B) according to their ranking as first, second or third class in social and intellectual qualities. Men falling between A and B (100% $-(A+B)$) are those who do not immediately display either marked superiority or inferiority. They are indispensable en masse but replaceable individually without difficulty.

Personal Ranking	Intellectual Ranking					
	1		2		3	
	A	B	A	B	A	B
1	50	5	40	10	10	20
2	40	10	20	15	5	30
3	30	20	5	30	0	50

You will observe that in all but the 3–3 category (the lower right-hand box) I have estimated some percentage of the men to be potential top-notchers. The reason for this is that young men often

[1] Presented before the Chemical Engineering Division at the Annual Meeting of the A.S.E.E., Troy, N. Y., June 1949.

overcome their handicaps during their first few years out of school. Perhaps there should be at least a 1% figure in that last box also, for I have been all too often painfully confounded by the considerable financial success of a seemingly hopeless case, particularly when he set up some small business of his own. But then, I am speaking only of success in *industry*.

You will notice that even in the 1–1 box (upper left-hand corner), I have estimated 5% of initial failures. Some of my colleagues, indeed, would argue that this figure is too low. The individuals represented are largely maladjusted types, typically exhibiting other exaggerated self-esteem or lack of adaptability to a subordinate position. It seems probable that most of them eventually straighten themselves out, but this may not be until 5 or 10 years after graduation.

Company Practices

I have observed that the larger companies, and particularly the very largest ones, are often quite willing to gamble on a man who ranks as high as No. 1 in either column, even though he may rank as low as No. 3 in the other. These large companies frequently have guidance programs which can upgrade a man to some extent; they also have some specialized, narrow job classifications which can be satisfactorily filled even by seriously one-sided people.

In the smaller companies, on the other hand, the emphasis is more frequently on adaptability and breadth, rather than specialization. These companies, of which my own is a fair example, can ill afford to employ any man who ranks as low as No. 3 in either column, even though he may rank No. 1 in the other. In fact, a man who falls in the 2–2 group will probably go ahead faster in the smaller companies than in the larger ones, because he will not have to compete on any ground with 1–3 and 3–1 specialists. There are rarely any cubbyholes in the small company for brilliant eccentrics.

The interviewer of recent graduates judges social qualities partly by visual observation during an interview, but also to a large extent from the applicant's record of extra-curricular activities in college. Certain kinds of extra-curricular activity are reliably indicative of desirable social qualities, while others produce a negative impression. For example, a man who lists the Stamp Club and the Chess Team as his outside interests in college probably would not have the ability to get along with his fellow men that could be expected from one who went out for boxing or even football or the Junior Prom Committee. I wish that someone would tell the senior chemical engineers that membership in the Student Chapter of the A.I.Ch.E. should not be listed in an employment application as an extra-curricular activity.

As to judging intellectual qualities, the transcript of an applicant's college record is usually a pretty accurate gauge. There are cases, however, in which a few low grades should not be given much weight, because of extenuating circumstances. For some time now I have been content to ask applicants the grades they obtained in thermodynamics and physical chemistry, for I believe these are the most difficult, and among the most important of all chemical engineering subjects. They are also the hardest to "make up" after leaving school.

Doubtless there are many of you who are ready to quarrel with the percentages shown in my table. It will be quite impossible to argue the point, however, since my standards for achievement or preliminary ranking cannot be expressed numerically. The percentages are purely relative, but I believe they are reasonably self-consistent. I could easily devote all of my remaining remarks to the implications of this table, but I shall pass on and leave it as a target for the subsequent discussion period.

Needs in Chemical Industry

I have found a recurrent need in the heavy chemical industry for a type of individual often described informally as a "plant chemist." Such people have been difficult to find, and when one is found, he may prove to have gained his degree in either chemistry or chemical engineering. Properly, the chemical engineer should easily surpass the chemist in this occupation, considering the duties involved. A good plant chemist should combine a thorough awareness of the technical tools of our trade with the ability to subordinate his striving for perfection to the practicalities of the business. Some of you might think him too rough-and-ready in his thinking. It is to be realized, however, that in the heavy chemical industry either the low selling price of the product or the prohibitive expense of replacing fully depreciated heavy equipment often makes it pointless to go very far afield in search of solutions to problems. Too many graduates pop up with the suggestion that a mass spectrometer, costing $32,000, would be just the thing for plant impurity control. Considering the generally simple nature of heavy chemicals, there usually just *has* to be a cheaper analytical method. A good plant chemist will find it. Whether because of economic factors or, as the graduate often believes, lack of progressiveness, the small and medium sized chemical companies seldom back up their front line technical men with specialists or with complex laboratory equipment. This tends to discourage highly trained men and gives those in the 2–2 group a compensating advantage. Often they do not know any better than to make an effort to get the job done with their bare hands, where a smarter man would feel it a waste of time to make the effort without improved facilities.

The good plant chemist has a great capacity for independent work, without specific directions. He must know how to formulate questions as well as to find the answers, for frequently he must begin work without a well-defined project outline.

To earn a reputation as a good plant chemist, the young chemical engineer must be able to present his ideas convincingly to superiors who came up from the ranks without benefit of Walker, Lewis and McAdams, for they are many in the heavy chemicals industry. This requires the repression of a certain brashness. Graduates ought not to indulge even mentally in a slight condescension when they discover that the plant superintendent does not know the meaning of a word like "fugacity." They should realize that he is struggling with the same feeling while they display their ignorance of intra-plant nomenclature and practice. This point recalls to me the befuddlement I felt when I first encountered the oil refinery procedure of filling valve boxes with horse manure during the wintertime. Such an important fact seems somehow to have been omitted from Perry's Handbook.

It does not yet seem to be sufficiently emphasized to chemical engineering seniors that they must and normally will acquire new information more rapidly during their first two or three years in industry than they ever did in school, and that they cannot make the most of this learning period if they shy away from lowly technical activities. Very recently a fledgeling doctor of chemical engineering told me in the same breath that his sole interest was in continuous process development, but that he could not consider any job involving shift work. A companion difficulty with such young men is that they are far too greatly concerned as to their destination five or ten years hence. Beyond assuring himself that a job provides the opportunity for good experience for two years or so, I do not believe that the chemical engineering senior need greatly trouble himself about his future. Our profession affords exceptional freedom to move from job to job during the early years, and such movement is not without benefits in en-

hanced perspective and broadness of approach to technical problems.

Advanced Training

For many years, graduates at the B.S. and even the M.S. level have been encouraged to continue their technical studies by going to night schools. This emphasis on advanced training has had a pronounced effect, such that many applicants are not interested in a job unless it affords an opportunity for attendance at a nearby technical school. In many cases, I believe this zeal for further professional study is misplaced, particularly where a man does not have the scholastic ability nor the requisite attitude toward life to stake his success on sheer technical brilliance. Many of these men should be advised not to devote any more time to technical studies, and should instead begin to familiarize themselves with subjects like accounting, patent law, personnel management, and marketing. In the small and medium sized companies they will need to be well acquainted with at least some of these subjects before they are given major responsibilities. All too often a process shows unduly high operating costs simply because of some incongruity in the company's cost accounting practices. In such a case, a little knowledge of cost accounting will save the chemical engineer much fruitless technical study.

I can hardly leave this subject without some few remarks on the subject of poor report writing by chemical engineering graduates. Industrial leaders have complained about it for a good many years now without being very specific. I have found the young men to be for the most part entirely capable of writing lucid, grammatical sentences. At least 75% of those who are attractive prospects in other ways are also capable of composing a perfectly acceptable paragraph, but when a succession of paragraphs is called for, then it must be admitted that very few can do an acceptable job. I attribute this fact not so much to inadequate instruction in English or the alleged congenital inarticulacy of engineers, as to a simple lack of perspective. The young report writer does not realize what things are important and what unimportant. I am sure this is why so many beginners' reports start out with a tabulation of the data and conclude with the conclusions. After all, in a great many laboratory courses they know beforehand that Avogadro's Law, for example, has been pretty well established, and their attention is primarily directed to obtaining data which will not be in conflict with it. The conclusions they draw from college experimental work are foregone conclusions; method is emphasized at the expense of result. Another factor is that the young man feels a little uncertain of his competence, and nervously expects his data to be questioned. His natural inclination is to devote the important early portion of his report to a justification of his results, not realizing that they will probably be accepted at their face value as soon as they pass beyond his immediate supervisor.

I realize that this view merely condones ineptness in report writing, but I suspect that it cannot be improved very much in college. Fortunate is the graduate whose first supervisor has the patience to make him rewrite his first reports two or even three times until he gets the point.

It seems particularly appropriate to conclude by dwelling on the be-all and end-all of chemical engineering work. It would be so valuable to young men to acquire a due appreciation for the profit motive in business at an early age, that it would almost seem worthwhile to remind them of it at every turn during their college years. Textbooks on nontechnical business subjects often bear such titles as "Profitable Marketing Practices" or "Economical Traffic Management." Perhaps it would be a good thing if we adopted ones such as "How to Save Money in Heat Exchanger Design."

Organizing and Teaching Production Planning and Control

By C. B. FOOS

Associate Professor of Industrial Engineering, Georgia Institute of Technology

Probably the one field of human endeavor in which the United States has most clearly outdistanced the rest of the world is the field of industrial production. The great testing and proving ground of World War II brought forth many notable achievements, and demonstrated that no country has even an approximate monopoly of scientific and engineering knowledge and ability. But it proved even more positively what had been universally admitted prior to the event: that no country in the world can compare with the United States in industrial production efficiency and "know-how." That margin of superiority is even more decisive today, and represents a major bulwark to the national security in these troubled times.

Over the years, there has grown up in this country a great body of knowledge and techniques on how to make things, as distinct from the knowledge and techniques on how to design them so that they will perform their ultimate functions effectively. The typical manufacturing company will spend much more time and money in determining how to make its products than in determining their design; indeed, in nearly every high-production item, the final design is largely influenced by the production problems involved.

In view of these facts, it is somewhat surprising that a larger proportion of engineering college curriculum time has not been devoted to study of how to make things. Most curricula seem to be devoted to preparing men for research and product design. These phases are important, and require a high degree of ability and knowledge. The phase of how the product is to be made is also important, and also requires the use of high degree of ability and engineering knowledge; and it is my conviction that there is opportunity for many more engineers in the manufacturing phases of industry than in the design phases. I believe that the recognition of this fact by many men in responsible positions in industry, and their resulting advice to young men of their acquaintance, accounts for the growth of industrial engineering courses in recent years.

Definition of Industrial Engineering

We might define Industrial Engineering in simple language as "The art and science of doing things more efficiently." As such, it deals with people as well as with things; with management principles as well as with machines and equipment; with large scale problems and with details of them. To all of the multitudinous and constantly changing problems of production, it brings a characteristic engineering approach—objective, analytical, and cost minded.

The design of production planning and control systems, and much of the work within them, is a generally recognized sub-field of industrial engineering, and every fully qualified industrial engineer and manufacturing executive should have a working knowledge of its general principles, at least. It is usually carried on as a functional staff activity, interlinked

and integrated with the other staff and executive functions through which management operates the enterprise. Its exact scope will vary with the organization, but for purposes of discussion we may limit it to the following activities, which take place after the general production goals have been set and the product designed: determination of what to make, what to buy; routing; scheduling; materials control, including storeskeeping and inventory control; preparation of "Manufacturing Paperwork"; dispatching; follow-up; and the maintenance of production information and records. We will not include the activities of manufacturing methods development and improvement, quality control, or direct supervision of production itself.

All the recognized curricula in Industrial Engineering, and most of those in Industrial Management and similarly titled courses, cover this subject matter in some form. Some have a separate course in the subject; others take it up as part of a more inclusive course or sequence of courses. It makes little or no difference; the important things are the way the subject is approached and the participation of the student in the course. To my mind, the worst mistake we can make in teaching production planning and control is to make it a lecture and reading course, devoted mainly to description and to the stating of general principles. In my opinion, production planning and control should be taught as a *design* course; the whole aim should be to develop in the student an appreciation of its fundamentals and a facility in using them to solve individual problems. I am a great believer in problems as a means of teaching and bringing out fundamental principles; problems that make the student think, not those which involve only well-defined procedures and "turning the crank" to arrive at the correct answer. In this respect, production control is no different from the other applied sciences, such as machine design or quantitative analysis; the fundamentals are bound up with the nature of the problem, and the techniques and tools of the science were developed in the course of solving the problems constantly arising in dealing with its subject matter.

In essence, then, I feel that we should give the student a good grasp of certain basic ideas underlying and running through all the phases of production planning and control. This may be done by stating them clearly and in a number of different ways; by illustrating the principles by example; and finally and most important, by requiring him to apply these ideas in solving problems. I feel very strongly that our aim should not be the mere imparting of knowledge or understanding of general principles, but the development of ability to use this knowledge effectively in solving any and all problems which may come up in connection with it.

Basic Concepts

What are the basic concepts which shape the design of production planning and control systems and operations? If we asked twenty successful practitioners of the art to prepare their own list of fundamentals, we would probably get twenty different lists. Most of them, however, would include these ideas, in varying language:

Organization and Teamwork: The production planning and control functions are an integrated part of the entire management team, carrying on their own assignment, depending on other functions and having other functions depending on them. Organization and coordination—official and informal—are essential.

Forecasting and Preplanning: Accurate forecasting of what will be required and what will happen—devising the best means of meeting the requirements and problems, before the event, with all the data and help available—preventing troubles from happening, rather than meeting them on an emergency basis when they occur—these make control a reality, and promote economy of effort,

maximum use of facilities, and minimum overall cost.

System and Standard Operating Procedures: Successful production control requires the handling of great quantities of detail, accounting for myriads of individual items, operations, instructions, and bits of information. Effective handling of this detail is impossible without an orderly, systematic procedure. Working out the "better way" to handle it into an integrated system, describing and utilizing these methods by a set of Standard Operating Procedures, is a real design problem; its effective solution pays very large and continuing dividends.

Controls, Checks, and Management by Exception: These flow from, and are made possible by, system and standard procedures. They permit management and related specialized skills to be used at their full efficiency, rather than hampering them with routine work. They provide for self-regulation of the system, and automatic protection in case of serious trouble, in a way which is at times strikingly similar to the working of automatic electrical control systems.

Economic Balance and the Law of Diminishing Returns: Again and again, we find that the "right answer" involves a balancing of what we get against what it costs us—whether it be in determining economic lot size, the proper quality standard, the amount of time and effort to be spent on working out a better method, the number of buyers in a purchasing department, or any of a thousand other problems which depend on a balance of two or more factors.

Scheduling: Planning and arranging for things to happen at the right time with respect to each other. Time is of the essence in all of the work of the production control function.

Human and Mechanical Imperfection: In spite of the best possible planning and control, people make mistakes or fail to do what is expected of them; and all material things have their imperfections, breakdowns, and failures, some of them impossible to prediet accurately. Production planning and control must provide for the speedy recognition of such failures when they do happen, and provide for the action to be taken in such cases.

Information, Reports, Records: Part of the job of production control is to keep accurate records of the status of all the elements of production; to see that those records which will be useful in the future are preserved in a manner which makes them easy to use; and to make reports, abstracts, and summaries from this information for the use of management or other groups which may need them. Much of this information is needed by the production control group itself in planning for future production.

This list could be amplified and extended, but it will serve to illustrate the kind of concepts and approach which influence the design of production planning and control activities.

Teaching Approach

In my courses in production planning and control, I try to take up the subject matter as a series of jobs which have to be done; the conditions of the job impose the problem, and the right answer, or the good answers (there may be several, about equally good) result from the application of the principles to the conditions. I try to show how the same problem, under different conditions, can call for very different answers; for example, a very well worked out inventory control system, excellent for a hardware manufacturer, might be an extremely poor one for a heavy machinery manufacturer, and vice-versa; and yet basically their problems are similar. One of the early subjects we take up is a survey of the factors which affect the size and complexity of the production control group, and the manner in which it should be organized. This brings out very clearly the immense variety of types of manufacturing, and the fact that each production planning and control problem solution should be "tailor-made" to the needs

of the manufacturing enterprise. And yet it becomes evident, as we go through these "jobs" or "functions," that the same fundamental principles and approaches determine the solution to problems which do have very different answers. I take up examples of "how it is done in the XYZ Co." as being typical solutions worked out in practice, and analyze them in terms of what principles have been applied and how effectively and economically they do the job required by the particular set of conditions in the XYZ Co. Then I put a problem to the student—either in class discussion or as a quiz-type, graded problem—and ask him to give me his solution and the reasons for it. We get more out of this than out of the examples.

As mentioned before, I am a great believer in having students work out problems which require thought and effort—either by themselves or with their fellows, with or without the help or suggestions of the instructor. I try to have some under each of these categories, because each has its benefits. One of the real difficulties with this method is the necessity of continually having different problems, particularly since we have several sections of the course every quarter. If the student can get the "word" as to the right answer before he starts, it greatly lessens the value of the problem to his learning.

As for subject matter and topics discussed, I believe there is room for wide latitude in scope and amount of detail given. It is entirely a matter of how much time is available and what has been taken up in other courses in the curriculum.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Michigan	Wayne University	May 20, 1950	H. M. Hess, Wayne University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	University of Maryland	May 6, 1950	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13, & 14, 1950	F. H. Thomas, University of Buffalo

New Members

AHUJA, VICTOR B., Secretary General and Head of the Civil Engineering School, Instituto Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, J. A. Focht.

ALLEE, DAVID W., Assistant Director for Ind.-Tech. Ed., Long Island Agric. & Tech. Institute, Farmingdale, N. Y. L. A. Emerson, L. L. Jarvie.

AMORES, JOSE E., Director of the Escuela Preparatoria, Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, B. N. Gafford.

ANDERSON, ERNEST W., Research Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. A. Higdon, E. H. Ohlsen.

ANDERSON, JOHN R., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. O. W. Potter, H. D. Myers.

ANDERSON, VINCENT W., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. O. W. Potter, L. J. Quaid.

ARNOLD, HENDRICK J., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, H. W. Risteen.

BAHLI, FREDDY, Burma State Scholar, Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. K. L. Wildes, W. H. Radford.

BALBER, AMNON, Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. M. W. Roney, C. L. Foster.

BARNES, ROBERT H., Instructor in Engineering, University of Rochester, Rochester, N. Y. A. D. Taylor, H. W. Leet.

BECKEMEYER, HARRY J., Associate Professor of Ceramic Engineering, Iowa State College, Ames, Iowa. C. M. Dodd, A. Higdon.

BERGSETH, FREDERICK R., Assistant Professor of Electrical Engineering, University of Washington, Seattle, Wash. F. D. Robbins, L. M. Stout.

BETROS, LOUIS A., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. M. W. Roney, C. L. Foster.

BEYER, FRANK R., Instructor in Engineering Mechanics, Wayne University, Detroit, Mich. R. T. Northrup, H. R. Lissner.

BIAGI, JOSEPH M., Assistant Professor of Civil Engineering, Marquette University, Milwaukee, Wis. O. N. Olson, R. J. Smith.

BOLSTAD, MILO M., Associate Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. R. H. Luebbers, R. L. Scorah.

BONAR, ALBERT J., Instructor in Civil Engineering, University of Houston, Houston, Tex. L. J. Castellano, W. B. Lowe.

BRADBURY, DOUGLAS W., Assistant Professor of Drawing and Design, Clemson College, Clemson, S. C. J. H. Sams, S. B. Earle.

BRADISH, JOHN P., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, R. J. Smith.

BRANOVAN, LEO, Instructor in Mathematics, Marquette University, Milwaukee, Wis. A. C. Moeller, R. J. Smith.

BRENKERT, KARL, JR., Full Time Teaching Assistant, Mechanical Engineering, University of Utah, Salt Lake City, Utah. W. J. Cope, P. J. Waibler.

BRIELMAIER, ALPHONSE A., Professor of Civil Engineering, Washington University, St. Louis, Mo. A. W. Brust, E. O. Sweetser.

BROCK, CHELSEY L., JR., Instructor in Chemical Engineering, University of Houston, Houston, Tex. C. A. Vogt, W. B. Lowe.

BROWN, FRANCIS W., Assistant Professor of Chemistry, Clarkson College, Potsdam, N. Y. W. H. Allison, C. Allen.

CAMARENA, ELIOT, Head, Administration Department, Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, B. N. Gafford.

CARROLL, PENN L., U. S. Department of State Visiting Professor of Electrical Engineering, Instituto de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, B. N. Gafford.

CHAMBERS, WILLIAM R., Professor and Head, Mechanical Engineering, University of Tennessee, Knoxville, Tenn. A. B. Bronwell, H. B. Batchelor.

CHASE, WILLIAM F., Instructor in Mechanical Engineering, University of Detroit, Detroit, Mich. H. Gudebski, C. G. Duncombe.

CLARK, JOHN W., Teaching Fellow, Mechanical Engineering, University of Michigan, Ann Arbor, Mich. J. A. Bolt, E. Young.

CORNING, LEO H., Manager, Structural and Railways Bureau, Portland Cement Association, Chicago, Ill. A. B. Bronwell.

CRONVICH, JAMES A., Professor of Electrical Engineering, Tulane University, New Orleans, La. C. W. Ricker, M. Forsman.

CROWDER, JERAL J., Petroleum Engineer, Quintana Petroleum Corporation, Houston, Tex. W. B. Lowe, L. J. Castellano.

CUMMINS, KENNETH D., Instructor in Civil Engineering, University of Detroit, Detroit, Mich. H. Gudebski, C. G. Duncombe.

CURTIS, CHARLES V., Director of Technical Publications, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

DEICHERT, ROBERT W., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y. C. C. Carr, K. E. Quier.

DEISTER, WILLIAM A., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

DELICH, MICHAEL, Instructor in Mechanical Engineering, Michigan State College, East Lansing, Mich. L. C. Price, J. M. Campbell.

DENNY, C. E., Instructor in Mathematics, Central College, Fayette, Mo. A. B. Bronwell, R. L. Scorah.

DEWEY, HARRY M., Associate Professor of Agricultural Engineering, Idaho State College, Pocatello, Idaho. H. O. Ritland, A. L. Lillibridge.

DILLENBECK, HAROLD L., Instructor in Engineering, Pennsylvania State College, State College, Pa. K. L. Holderman, V. E. Neilly.

DODD, ROBERT W., President, Cogswell Polytechnical College, San Francisco, Calif. A. B. Bronwell, Thorndike Saville.

DOTY, ROBERT L., Instructor in Electrical Engineering, Iowa State College, Ames, Iowa. R. W. Ahlquist, A. Higdon.

DOUGLASS, DAVID R., Instructor in General Engineering, University of Washington, Seattle, Wash. E. R. Wilcox, R. Q. Brown.

DRECHSLER, FRANK S., Instructor in Mechanical Engineering, University of Delaware, Newark, Delaware. D. L. Arm, W. F. Lindell.

DRINKER, PHILIP, Professor of Industrial Hygiene, Harvard School of Public Health, Boston, Mass. L. Silverman, G. M. Fair.

DUBOSE, LAWRENCE A., Instructor in Civil Engineering, Texas A. & M. College, College Station, Tex. R. L. Peurifoy, R. M. Holcomb.

DUHNE, CARLOS, Head, Chemistry Department, Instituto Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, J. A. Focht.

DUKE, ALBERT L., Instructor in Electrical Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. H. D. Craun, C. P. Philpot.

DWINNELL, JAMES H., Assistant Professor of Aeronautical Engineering, University of Washington, Seattle, Wash. F. S. Eastman, H. E. Wessman.

EUBANKS, WILLIAM H., Instructor in Drawing, Mississippi State College, State College, Miss. H. P. Neal, C. P. Marion, Jr.

EVANS, FRANK E., Instructor in Electrical Engineering, N. Y. State Institute of Applied Arts and Sciences, White Plains, N. Y. H. Halsey, D. C. Stoll.

FANNING, CLYDE L., Assistant Chairman, Machine and Wood Shops, General Motors Institute, Flint, Michigan. F. L. Mackin, G. R. Cowing.

FARBER, ERICH A., Assistant Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. L. A. Wilson, J. R. Akerman.

FARQUHARSON, KENNETH J., Assistant Professor of Engineering, University of Missouri, Columbia, Mo. R. L. Scorah, H. O. Croft.

FELDMAN, DAVID, Instructor in Electrical Engineering, The Cooper Union, New York, N. Y. E. W. Starr, P. Nudd.

FINCH, ROGERS B., Assistant Professor of Textile Technology, Massachusetts Institute of Technology, Cambridge, Mass. J. A. Hrones, J. E. Arnold.

FLEMING, ROBERT W., Instructor in Mechanical Engineering, University of Wisconsin, Madison, Wis. A. L. Larson, B. G. Elliott.

FROULA, HENRY C., JR., Lecturer in Engineering, University of California, Los Angeles, Calif. C. M. Duke, W. L. Orr.

FULLER, GEORGE M., Instructor in Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

GAUTHIER, VICTOR J., Assistant Professor of Mechanical Engineering, New York University, New York, N. Y. A. H. Church, E. A. Salma.

GLESS, GEORGE E., JR., Assistant Professor of Electrical Engineering, University of Colorado, Boulder, Colorado. W. C. DuVall, L. A. Bingham.

GOODSTEIN, ROBERT, Instructor in Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

GRAY, GEORGE A., Assistant Professor of Civil Engineering, Clarkson College, Potsdam, N. Y. W. H. Allison, J. H. Davis.

GRATZER, LOUIS B., Research Associate, Aeronautical Engineering, University of Washington, Seattle, Wash. E. D. Engel, F. S. Eastman.

GREAVER, LAWRENCE, Assistant Professor of Drawing, University of Virginia, Charlottesville, Va. R. E. L. Gildea, J. L. Vaughan.

GRIFFIN, NORVILLE D., Assistant Professor of Engineering, Oklahoma A. & M. College, Stillwater, Okla. H. P. Adams, E. R. Stapley.

GROGAN, WILLIAM R., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. J. E. Mulligan, D. E. Howes.

GRUNENFELDER, J. GEORGE, Professor of Metallurgy, Montana School of Mines, Butte, Mont. A. E. Adami, D. W. McGlashan.

GUNDLACH, JOHN T., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y. C. C. Carr, K. E. Quier.

GUTHRIE, GEORGE W., Assistant Instructor in Engineering Drawing, Marquette University, Milwaukee, Wis. T. J. Riebeth, A. C. Moeller.

HACKETT, ARTHUR J., Instructor in Engineering, N. Y. State Institute of Applied Arts and Sciences, White Plains, N. Y. H. Halsey, D. C. Stoll.

HAINES, HOWARD N., Assistant Professor of Civil Engineering, Duke University, Durham, N. C. R. E. Lewis, O. Meier, Jr.

HAIRSTON, RAYMOND L., Assistant Director, Cooperative Program, University of Houston, Houston, Texas. W. T. Kittinger, L. J. Castellanos.

HALL, FRANCIS T., JR., Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. E. B. Stavely, A. P. Powell.

HAMMER, B. B., Associate Professor of Aeronautical Engineering, Texas A. & M. College, College Station, Tex. L. P. Thompson, L. E. Flanagan.

HAMMETT, CECIL E., Professor and Head, Engineering Drawing, Alabama Polytechnic Institute, Auburn, Ala. L. M. Sahag, J. E. Hannum.

HANSON, LORING O., Associate Professor of Applied Mechanics, University of Kansas, Lawrence, Kans. F. L. Brown, H. L. Kipp.

HARLOFF, ROBERT E., Instructor in Mechanics, Marquette University, Milwaukee, Wis. R. J. Smith, R. J. Panlener.

HARRIS, JAMES B., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

HARTSAW, WILLIAM O., Instructor in Engineering, Evansville College, Evansville, Ind. J. F. Sears, M. C. Bishop.

HASSEL, ELMER W., Head, Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. R. J. Ungrodt, F. J. Van Zeeland.

HEADDY, PAUL B., Assistant Professor of History, Rose Polytechnic Institute, Terre Haute, Ind. J. L. Bloxsome, C. E. Kircher, Jr.

HEAD, ROBERT R., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. B. H. Spurlock, W. S. Beattie.

HEISE, HENRY A., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, R. J. Smith.

HOBSON, JOSEPH R. A., JR., Lecturer on Industrial Engineering, Columbia University, New York, N. Y. W. W. Waite, R. L. Lybrly.

HOLLAND, CHARLES T., Professor of Mining Engineering Virginia Polytechnic Institute, Blacksburg, Va. W. A. Murray, H. F. Trent.

HOPE, PABLO H., Director de la Escuela de Ingenieria, Instituto de Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, J. A. Focht.

HORGAN, JAMES D., Instructor in Electrical Engineering, Marquette University, Milwaukee, Wis. J. F. H. Douglas, R. J. Smith.

HORI, SHIZUO, Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. T. J. Higgins, J. R. Price.

IMHOFF, JOHN L., Assistant Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. N. R. Hall, A. O. Lee.

IRWIN, VERYL W., Assistant Chairman, Mechanical Engineering, General Motors Institute, Flint, Mich. C. A. Brown, R. H. Spahr.

JABLONSKI, GEORGE G., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, R. J. Smith.

JAHREN, CHARLES E., Instructor in Science, Austin Junior College, Austin, Minn. E. R. Johnston, G. C. Priester.

JONES, MACK C., Coop Vocational Advisor, University of Houston, Houston, Texas. W. T. Kittinger, L. J. Castellanos.

JONES, ROBERT S., Associate Professor of Mechanical Engineering, Wayne University, Detroit, Mich. R. T. Northrup, W. J. David.

KEETON, JOHN R., Instructor in Engineering, Arkansas State College, State College, Ark. R. B. Blakestad, A. B. Bronwell.

KEELER, ROBERT J., Assistant Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. W. A. Murray, B. M. Widener.

KENYON, CHARLES D., Professor of Physics, Tri-State College, Angola, Ind. J. G. Radcliffe, L. S. Ax.

KEUFFEL, AUGUST, Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. A. W. Luce, K. E. Quier.

KEYSER, CARL A., Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst, Mass. J . B. Longstaff, J. D. Swenson.

KIRK, EDWIN R., Associate in Research, North Carolina State College, Raleigh, N. C. J. S. Doolittle, W. E. Adams.

KLEINT, RODERIC E., Instructor in Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

KLUG, STANLEY H., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y. C. C. Carr, K. E. Quier.

KOSKI, PAUL I., Instructor in Mechanical Engineering, Michigan College of M. & T., Houghton, Mich. R. R. Hagen, H. C. Hamilton.

KOTTMAN, ROBERT H., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, R. J. Smith.

KRANTZ, WILLIAM H., Instructor in Civil Engineering, Lafayette College, Easton, Pa. J. Marthinsen, J. E. Rush.

KRUPNIK, STANLEY, JR., Instructor in Electrical Engineering, Marquette University, Milwaukee, Wis. J. F. H. Douglas, R. J. Smith.

LABANAUSKAS, PAUL J., Instructor in Electrical Engineering, Marquette University, Milwaukee, Wis. J. F. H. Douglas, R. J. Smith.

LEIGH, ALFRED H., Professor of Civil Engineering, Michigan State College, East Lansing, Mich. C. O. Harris, D. J. Renwick.

LEWIS, CHARLES F., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. C. G. Mumford, G. C. Watson.

LIN, TUNG-HUA, Associate Professor of Aeronautical Engineering, University of Detroit, Detroit, Mich. K. E. Smith, H. Gudebski.

LIND, MERRIL S., Instructor in Electrical Engineering, Michigan College of M. & T., Houghton, Mich. V. O. York, G. W. Swenson.

LINDER, CLARENCE H., Assistant to General Manager, Apparatus Dept., General Electric Co., Schenectady, N. Y. D. S. Roberts, M. M. Boring.

LINGELBACH, DANIEL D., Instructor in Electrical Engineering, University of Arkansas, Fayetteville, Ark. A. S. Brown.

LIPPERT, JOHN W., Instructor in Engineering English, University of Minnesota, Minneapolis, Minn. L. O. Guthrie, G. J. Schroepfer.

LOPEZ-BARANANO, JOSE M., Head, Mechanical Engineering, Instituto Tecnologico de Monterrey, Monterrey, N. L., Mexico. W. R. Woolrich, J. A. Focht.

LOVAN, JAMES E., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

LOWE, GEORGE B., Drainage Engineer, G. B. Lowe Company, Pasadena, Texas. J. E. Hoff, W. T. Kittinger, Jr.

LUND, PHILIP S., Instructor in Electrical Engineering, Michigan College of Mining and Technology, Houghton, Mich. V. O. York, G. W. Swenson.

LUSHINE, JAMES A., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. O. W. Potter, H. D. Myers.

LYTLE, NELSON E., Instructor in Engineering, Olympic Junior College, Bremerton, Wash. P. O. Vulliet, F. H. Rhodes, Jr.

MACKEN, DON R., Coordinator of Conferences, University Extension Division, University of Tennessee, Knoxville, Tenn. S. King, J. B. Lewis.

MACKENZIE, WILLIAM NEAL, President, Treasurer and Director, Terryville Water Co., Wallingford, Conn. W. W. Waite.

MCCALLICK, HUGH E., Chairman, Aeronautics Dept., University of Houston, Houston, Tex. W. B. Lowe, G. H. Garver.

MCCLARNON, JOHN J., Instructor in Chemistry, Pratt Institute, Brooklyn, N. Y. F. C. Disque, Jr., K. E. Quier.

MCELWEE, LAWRENCE T., Coordinator, University of Detroit, Detroit, Mich. H. Gudebski, C. G. Duncombe.

MCGARRY, JOHN F., Associate Professor of Engineering, University of California, Berkeley, Calif. M. P. O'Brien, R. G. Folsom.

MCINTIRE, SUMNER H., Associate Professor of Physics, Norwich University, Northfield, Vt. W. D. Emerson, C. A. Renfrew.

MCKEVITT, JOHN, Instructor in Civil Engineering, Marquette University, Milwaukee, Wis. O. N. Olson, R. J. Smith.

MCKINNON, ROY A., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. R. M. Lindquist, B. J. Robertson.

MAIN, KENNETH L., Instructor in Electrical Engineering, Iowa State College, Ames, Iowa. A. Higdon, R. W. Ahlquist.

MANNING, EDWARD G., Instructor in Electrical Engineering, North Carolina State College, Raleigh, N. C. J. H. Lampe, W. D. Stevenson, Jr.

MARKOWITZ, JESSE, Assistant Professor of Drafting, College of the City of New York, New York, N. Y. C. H. Kent, G. A. Guerdan.

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MASER, HAROLD T., Manager, Employee Relations Division, International General Electric Company, Schenectady, N. Y. M. M. Boring, C. F. Terwilliger.

MICHEL, PHILIP L., Associate Professor of Aeronautical Engineering, North Carolina State College, Raleigh, N. C. K. P. Hanson, F. C. Brown.

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MILLER, RALPH B., Assistant Professor of Engineering, Michigan College of M. & T., Houghton, Mich. M. W. Hughes, A. P. Young.

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OTHMER, RICHARD T., Assistant Professor of Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

PAUL, RAYMOND F., Instructor in Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

PEIRCE, GILBERT H., JR., Instructor in Mathematics, Marquette University, Milwaukee, Wis. A. C. Moeller, R. J. Smith.

PERRY, IRVING D., Instructor in Electrical Engineering, N. Y. State Institute of Applied Arts and Sciences, White Plains, N. Y. H. Halsey, D. C. Stoll.

PETER, WILLIAM G., Instructor in Mechanical Engineering, Arkansas State College, State College, Ark. R. B. Blakestad, A. B. Bronwell.

PLENGEY, WILLIAM D., Instructor in Electrical Engineering, North Carolina State College, Raleigh, N. C. J. H. Lampe, W. D. Stevenson, Jr.

POLLARD, ROBERT Q., Instructor in Electrical Engineering, University of Rochester, Rochester, N. Y. A. D. Taylor, C. H. Dawson.

POWLEY, GEORGE R., Associate Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. W. A. Murray, G. C. Barnes, Jr.

RAMEY, ROBERT L., Instructor in Electrical Engineering, North Carolina State College, Raleigh, N. C. J. H. Lampe, W. D. Stevenson, Jr.

RAO, PRATAPAGIRI VENKATA BHUJANGA BHOOSHANA, Assistant Professor of Mechanical Engineering, College of Engineering, Kakinada, South India. C. O. G. Wittig, L. S. Churchill.

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REINHART, WILLIAM A., Instructor in Applied Mechanics, Iowa State College, Ames, Iowa. A. Higdon, A. W. Davis.

REYNOLDS, RALPH K., Teaching Fellow, Mechanical Engineering, Oregon State College, Corvallis, Ore. G. W. Gleeson, H. H. Paul.

RICKARD, CORWIN L., Instructor in Mechanical Engineering, University of Rochester, Rochester, N. Y. A. D. Taylor, L. D. Conta.

RIDGLEY, C. HERBERT, Staff Asst., Apparatus Engrg., General Electric Company, Schenectady, N. Y. P. L. Alger, T. M. Linville.

RIES, HAROLD C., Instructor in Chemical Engineering, Tufts College, Medford, Mass. C. F. Gurnham, F. N. Weaver.

RITTER, ROBERT L., Instructor in Engineering Drawing, Marquette University, Milwaukee, Wis. T. J. Riebeth, R. J. Smith.

ROBB, DAVID D., Assistant Professor of Electrical Engineering, Iowa State College, Ames. Iowa. A. Higdon, R. W. Ahlquist.

ROGERS, WILLIAM W., Head, Mechanical Engineering Dept., Long Island Agric. and Tech. Institute, Farmingdale, N. Y. L. A. Emerson, D. W. Allee.

ROSSELL, EVE., Lecturer on Industrial Engineering, Columbia University, New York, N. Y. W. W. Waite, A. T. Schwab.

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SALERNO, JOSEPH, Instructor in Electrical Engineering, Clarkson College, Potsdam, N. Y. A. R. Powers, F. A. Record.

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SCHNEYER, RAYMOND I., Assistant Professor of Aeronautical Engineering, University of Michigan, Ann Arbor, Mich. W. C. Nelson, E. H. Conlon.

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SCOTT, PEARL A., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

SHAHDAN, PETER, Instructor in Mathematics, North Carolina State College, Raleigh, N. C. H. J. Fisher, C. G. Mumford.

SHARP, DONALD W., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. H. P. Adams, C. L. Foster.

SHERMER, CARL L., Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. D. J. Renwick, R. L. Vanderslice.

SHODRON, JOHN G., Assistant Professor of Civil Engineering, Marquette University, Milwaukee, Wis. O. N. Olson, R. J. Smith.

SIBERT, HAROLD W., Professor of Aeronautical Engineering, University of Colorado, Boulder, Colorado. C. L. Eckel, W. C. DuVall.

SIDWELL, CARROLL V., Professor of Petroleum Production Engineering, University of Tulsa, Tulsa, Okla. R. L. Langenheim, W. L. Nelson.

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SNEED, CARL M., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. H. W. Woods, P. Ogden.

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SOLNICK, ROBERT L., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. B. J. Conta, L. R. Parkinson.

SOVRAN, GINO, Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. N. A. Hall, A. O. Lee.

STEIDEL, ROBERT F., JR., Instructor in Mechanical Engineering, Oregon State College, Corvallis, Ore. G. W. Gleeson, S. H. Graf.

STENE, JOHN K., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. O. W. Witzell, D. S. Clark.

STERN, HARRY, Instructor in Chemical Engineering, Iowa State College, Ames, Iowa. G. L. Bridger, H. A. Webber.

STERN, PETER, Instructor in Mechanics, Milwaukee School of Engineering, Milwaukee, Wisconsin. C. O. Werwath, Heinz Werwath.

STEWART, RICHARD B., Assistant Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. B. H. Spurlock, Jr., C. O. Wagner.

STEYER, CARL C., Instructor in Engineering Mechanics, University of Arkansas, Fayetteville, Ark. R. C. Wray, W. R. Spencer.

SPEWACHEK, ERWIN G., Instructor in General Engineering, Marquette University, Milwaukee, Wis. W. D. Bliss, R. J. Smith.

SWEET, ROBERT L., Associate Professor of Metallurgical Engineering, Michigan State College, East Lansing, Mich. R. W. Ludt, D. D. McGrady.

SWIFT, JAMES L., Instructor in Manufacturing Processes, Pratt Institute, Brooklyn, N. Y. O. Benedict, K. E. Quier.

SWINK, EARL T., Associate Professor of Agricultural Engineering, Virginia Polytechnic Institute, Blacksburg, Va. D. Thompson, J. A. Rives.

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THOMAS, THEODOR W., Associate Professor of Civil Engineering, University of Minnesota, Minneapolis, Minn. M. S. Kersten, G. J. Schroepfer.

THOMPSON, EVERETT D., Instructor in Engineering Mechanics, University of Arkansas, Fayetteville, Ark. R. C. Wray, G. F. Branigan.

THOMPSON, TRUET B., Assistant Professor of Electrical Engineering, Oklahoma A. & M. College, Stillwater, Okla. E. R. Stapley, C. A. Dunn.

TIMINERI, ANTHONY A., Instructor in Electrical Engineering, University of Buffalo, Buffalo, N. Y. S. S. Wagner, A. J. Kamm.

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VALPEY, ROBERT G., First Lt., U. S. Air Force, Ithaca, N. Y. R. E. Clark, H. H. Mabie.

VILANDER, NOBEL E., Instructor, Technical Department, Central Radio and Television Schools, Kansas City, Mo. M. W. Roney, C. L. Foster.

VOSE, THOMAS L., Assistant Professor of Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, R. J. Smith.

WALKER, JOHN W., Instructor in Mechanical Engineering, University of Tennessee, Knoxville, Tenn. R. L. Maxwell, J. F. Bailey.

WALLACE, ELLSWORTH E. R., Instructor in Engineering, Columbia University, New York 7, N. Y. W. W. Waite, D. B. Hertz.

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WATROUS, EDGAR R., Instructor in Mathematics, Milwaukee School of Engineering, Milwaukee, Wis. A. P. Jones, S. A. Eng.

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WHITMAN, ANDREW P., Instructor in Mechanical Engineering, Tulane University,

New Orleans, La. A. M. Hill, J. K. Mayer.

WILBUR, LESLIE C., Instructor in Mechanical Engineering, Duke University, Durham, N. C. W. H. Hall, R. S. Wilbur.

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WILSON, THOMAS H., Adjunct Professor of Chemical Engineering, University of South Carolina, Columbia, S. C. C. E. MacQuigg, R. L. Sumwalt.

WING, LAWRENCE A., Instructor in Civil Engineering, University of Maine, Orono, Maine. F. M. Taylor, W. S. Evans.

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WRIGHT, THOMAS A., JR., Assistant Professor of Electrical Engineering, Southern Methodist University, Dallas, Texas. W. W. Finlay, F. W. Tatum.

YAMUCHI, THOMAS T., Instructor in Electrical Engineering, University of Detroit, Detroit, Mich. H. O. Warner, H. Gudebski.

ZERBAN, ALEXANDER H., Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. N. R. Sparks, G. M. Dusinberre.

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Industry-College Relations: The Role of the Practicing Engineer*

By LAWRENCE A. APPLEY

President, American Management Association, 330 W. 42nd St., New York

This generation of engineers may well play a decisive role in determining whether our free economy will survive. For engineers contribute much of that unusual ability which will be needed in the solution of the great problems of our time. The productive genius of engineers will largely determine the potential *rate of economic progress,* since the causes of increasing productivity can be traced largely to technology. Engineers can make a necessary improvement in the control of *employment fluctuations* in which the cost of capital investment is a key factor. The solution of *labor-management disputes* requires the production of additional revenue to which the engineer can make an important contribution. The reconstruction or *foreign countries* and the development of *backward areas* will require the know-how of the American engineer. He will play an important role in sustaining and strengthening the *armed might* of democracies all over the world to meet the challenge of the rising tide of destructive forces beyond the seas. Thus, engineering is a national resource which may give us the competitive edge in managing successfully the troublesome problems we must solve, if we are to survive.

What a challenge this is to the engineering profession! If my estimate of tasks to come is correct, we shall in future need more men of good training, of basic ability and broad understanding. We shall have to educate men who can create and direct technical progress and at the same time be able to contribute to the mastery of these great problems of our industrial life. We shall have to prepare engineers for the increasingly important positions which they are occupying in industry and in the general life of the nation where they are performing a service vital to the well-being of the community. They will require great skills of an administrative and economic nature. Thus we shall need to train people not merely to preserve our economic system, but to improve and perfect it for the maximum good of all the people.

How can we then best meet these challenges? There are two major influences on the engineer's life—formal education and his career. There are two major groups—the engineering educator and the practicing engineer—one in the college and the other in industry, who can aid him in these two important phases of his life. What we need to do is to make the relations between the two groups closer and more intimate in order to bring out the greatest potentialities of the young engineer and to make his life well-rounded.

The process is like building a drawbridge across a chasm. There must be complete coordination of effort between the two groups so that when the engineer starts to cross from one end to the other, the two ends must meet so that he can proceed along a continuous road. You can imagine what would happen if two

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engineering concerns were to undertake the work of building a drawbridge separately or without coordination and consultation. The foundation, the structure, the nature of the material and its content—the construction of each firm would be different and except by pure coincidence a gap would be left. This gap would have to be bridged unaided and alone by those who attempt the crossing, and many may fail in the process.

If, therefore, the young engineer's life is to be one of full and unbroken service, then those who are working on both the educational and practical segment of his life must be in close agreement and harmony, just as if two groups want to build a perfectly working drawbridge. Both have to work in such a way that there is an unbroken and unimpeded way across it. Whether this gap is closed depends on the closeness with which formal educators and industrial educators work together.

Your president has asked me to devote my attention to what I should like to transcribe as making the ends of a drawbridge meet perfectly. He wants me to emphasize the responsibility of the individual practicing engineer in industry toward engineering education, to make my remarks directly applicable to him and to have him consider positive action. I would like to report to you some observations on engineering education as I have gathered them in my experience, in my contacts with practicing engineers and universities. Let me present them to you in a series of considerations. There are three major steps that seem essential in the closing of that gap: I. We must clarify the goals of engineering education and training; II. We must clarify the responsibilities of the engineer-educator and the practicing engineer; III. We must clarify the implementation of responsibilities.

Clarifying the Goals of Engineering Education and Training

The practicing engineer could make an important contribution by taking greater initiative in formulating jointly with the university educators common long-run goals in engineering education. From his experience he could indicate largely the technical and practical requirements, while the educators could contribute on the more basic and research aspects of engineering. Educators and practitioners might select outstanding representatives to meet regularly in the engineering societies, in centers of engineering and the various seats of learning to formulate the goals to help bridge the gap between university and industry. Since the practicing engineer benefits primarily, he must take the initiative more frequently, give more time and contribute more thought than he has done in the past.

Here then are some possible suggestions, of a tentative nature, merely to provoke thinking and to aid in clarification of goals. I have found it very helpful in working out the following ideas to draw on the reflections of some of those in charge of centers of advanced thought in engineering education, such as President Doherty and Provost E. D. Smith of the Carnegie Institute of Technology, Dean J. K. Finch and Professor Robert T. Livingston of Columbia, President McGregor of Antioch, the University of Wisconsin, M.I.T. and some other institutions as well as a number of practicing engineers.

The general goals of engineering education might be conceived to be of three interrelated kinds: 1. The development of technical competence; 2. the development of social competence; 3. the development of personal competence.

1. *Technical Competence*

Technical competence requires a thorough knowledge of the basic principles of the chief sciences—mathematics, physics, chemistry. Those principles need to be known in terms of concrete instances and applied in problems which represent reality. The engineer needs to have knowledge of the technical aids and where to find them. He should know

which sources and people to consult on his problems. He should be able to use his theoretical tools in practical work application, be able to set standards of performance, measure and meet them, either directly or be versatile in the use of alternative approaches.

2. *Social Competence*

The social competence of the engineer needs to be of three kinds—applicable to the plant, the community and the world as a whole. Social competence *within the plant* requires a knowledge of other business disciplines which have a bearing on engineering, especially knowledge of organization, materials, production flow, costing, pricing and selling.

Social competence in the *community* will require a real awareness of forces other than those of meeting purely technical standards and profit maximization, even though these are of the utmost importance. It means an education in, continued understanding of and a practical contribution toward the great problems of our time. There has been a neglect of these social responsibilities. Engineers have had to stick closely to the grindstone because of the high degree of competition. There has been a feeling that all which needed to be done is to improve technological performance and raise standards of living. But just as bigger living allowances by parents for their children do not buy by themselves greater happiness, neither does the mere increase in the economic income of the people bring about complete social stability. I do not deny the importance of the economic factor; indeed everyone must pay a tribute to the tremendous contribution made by engineers to our economic progress. At the same time, once the technical contribution is made, further responsibility is often not properly exercised in the solution of problems created by engineering progress right on the job in the plant, problems which may deeply affect the whole community. There remain the great problems of the effect of machine work on human beings, technological unemployment, the consequences of repetition and monotony, the sub-division of work and the assembly line. There is the matter of work fatigue, of incentives, of work surroundings, of safety and industrial health.

But we need to go beyond the confines of our plant and community and become aware of issues facing the *world* as a whole. There are vast and difficult international problems that we must tackle, if we are to survive. One that I have referred to already is the large bundle of economic issues. Here many believe that if you and the men whom you are training in the knowledge of how to make goods were permitted to organize production on a continental scale, you might, with your present know-how, double or triple the output of industry. This is the tremendous potentiality of the "engineering approach." But I should like to assert quite baldly that not all the problems of this century are capable of what might be called an engineering solution. The most formidable body of engineers would not save us from all our troubles. The great problems of this planet are not all reducible to problems of command over matter and the elements. Take for instance the grand question of war and Peace. It is abundantly clear that engineering know-how, while important, cannot by itself lead to the preservation of peace—without a police force or a proper balance of power. Mere techniques do not furnish guidance on ethical matters—we need a knowledge of philosophy to guide us in what is right. Engineering by itself is not a guide to what is practical in administration or politics.

3. *Personal Competence*

Human qualities are a vital factor in successful engineering. This is borne out by a famous study made by Dr. C. R. Mann under the Carnegie Foundation. This is how professional engineers and employers weighted the qualities (in per centages):

Character, integrity, responsibility, resourcefulness, initiative	24%
Judgment, common sense, scientific attitude, perspective	19.5%
Efficiency, thoroughness, accuracy, industry	16.5%
Understanding of men, executive ability	15%
Knowledge of fundamentals of engineering science	15%
Techniques of practice and business	10%
	100%

Thus personal qualities were regarded as accounting for 75 per cent of the success story, while engineering skill and ability accounts for the remaining quarter, in the sense that technical qualifications are assumed to be a certain part of a graduate's qualifications from a good engineering school. I do not believe that one can overstress the importance of these personal characteristics. For however good the technical competence and the realization of social competence, the human factor is the ultimate key in the rise of the young engineer, in the quality of his relationship to others and his ability to accomplish tasks through others, as well as his own happiness which is largely a function of the happiness of others with whom he is in contact.

Clarifying the Responsibilities of the Engineer-Educator and the Practicing Engineer

The second major task in bridging the gap between college and industry is the development of responsibilities toward that end on the part of the engineer-educator and the practicing engineer. This will be needed in order to carry out whatever goals of engineering education have been worked out. For merely to establish goals would leave undone the immensely important practical task of carrying them out. Again, in this development of responsibilities it will be essential to establish joint committees of colleges, societies and business organizations, representing educators and practitioners at all levels of interest. It will also be essential for the practicing engineer to participate. If there is no productive effort in his community toward the end of clarifying educational responsibilities, the practicing engineer ought to take the initiative or get someone to start the necessary clarification of responsibility. Broadly, the responsibilities are of two major kinds:

1. Establishing the basic educational functions;
2. Establishing the proper type of job satisfaction.

1. *Basic Educational Functions*

There is one widespread and common attitude which holds that the major and possibly the exclusive responsibility of educators in universities and in industry is to impart the maximum amount of technical knowledge. The student and young engineer should spend most or all his time on the study of engineering. There is tradition to support this attitude. There is the undisputable fact that engineering is a difficult, complicated subject which must be thoroughly understood, if the practitioner is to be competent. The individual needs to be highly specialized in his particular field of work. Professional ethics largely stress technical competence and a first-class technical performance, without much regard to social or human consequences. And the actual job of the engineer is often so closely circumscribed in industry that there is little chance to exercise social responsibilities. Finally, a purely technical training is easier, simpler and less expensive in terms of time and money.

But there is another, growing body of opinion which holds that the student should take advantage of opportunities which already exist in some colleges to become proficient in social and personal competence. A good training in social responsibilities would probably not be forgotten by the engineering student. It would make his college days more interesting and enjoyable. It would make

it possible for him to appreciate the human consequences of his technical performance. It would enable him to become a responsible citizen. It would enrich his personal life and his contacts with his fellows. And the engineering educator himself might improve his own standing in the academic surroundings, where the engineering school may be regarded as a trade school, not on a par with the schools of law and medicine, just because of that lack of a broader background.

Some argue that engineering schools already have business courses and cultural courses. Too often, however, these courses are so uninteresting and factual that they are forgotten as soon as the examination is over. Others argue that the practicing engineer bears the responsibility for developing the social and personal competence of the young engineer. But the practitioner may have lacked that same breadth of education which he is supposed to give to his successors. In any case, he will often lack the time to exercise this responsibility, while his young charge may be fighting too hard in the competitive struggle of industry to have the necessary time and energy to acquire social and personal competence.

Hence the practicing engineer should give serious consideration to the introduction of a broader cultural education in engineering schools. For it seems to me that the young men of today, probably regardless of whether they are veterans or not, have a greater feeling for and more interest in what I have called social competence than previous generations. They appear to demand such an education. To give one example, two young men in my acquaintance who both have a high aptitude in engineering, were attending engineering schools, but quit for liberal arts schools because they urgently wanted a broader education.

If then the goals of social and personal competence are recognized, it will be the engineer—educator who should assume the responsibilities for meeting them, and the practicing engineer should provide the spur, the guidance and the encouragement.

2. *Types of Job Satisfaction*

There is again a sharp cleavage on job satisfaction. Some hold that all that needs to be done is the prospect of financial rewards. But it is not clear whether financial incentives are adequate and, if they are, whether they form a good enough incentive. Such doubts seem to be in the following story of a young engineer whose experience and observations you may like to hear:

"The vocational guidance of prospective engineers at the formal educational level often takes the form of talks by prominent engineers of the local community. More often than not these talks are accompanied by pictures of the Empire State Building, the Golden Gate Bridge and the Boulder Dam or stories about the adventures of great engineers and builders. The accent is often on the successful, independent engineer and the profession is painted in the brightest colors. The impression is taken away from these lectures that engineering does offer the greatest possible rewards, both social and financial."

This was the young man's job expectation. And here is his job experience as he observed himself and others—not necessarily typical, but perhaps a straw in the wind:

"The hired engineer starts usually in a training course that typically runs for 2 or 3 years. During this time the salary is uniformly low, at the present time often lower than that of a semi-skilled workman in the factory. The argument usually is that the company is losing money on the young engineer for the first few years and therefore cannot afford to pay more. It is unfortunately true, however, that what is being taught to the engineer in the company training program he either knows already or could pick up in less than half the time that the program allows for it. Moreover, he may soon be expected to do the same type of work that oldtimers do at a much higher salary. In many cases the exploitation is too obvious not to cause re-

sentment. Only in a few companies does the training program stand up in scope and difficulty of subject matter to the university courses that the engineer passed through. Moreover, by talking to other engineers in the company it does not take the new man long to discover that even after 20 years he is not likely to earn a substantial income with the large corporation.

"But there are other setbacks at the outset. The engineer finds himself in competition not only with the other engineers in the company, but he finds that there are many who did not travel the long road through college but who are still competing with him for the better jobs. There are draftsmen, technical school graduates, old-timers who worked their way up through the company to occupy the same, or better, positions than the graduate engineer. The company does not necessarily draw a line between the graduates and the non-graduates. Finally, the line to the top seems endless."

Whatever the correctness of this young engineer's experience, responsibilities that might be considered by the practicing engineer may include:

a. Continuous study of the demand for engineers. The supply and demand for engineers seems to behave like the economic cycle for agricultural products—when there is a shortage of engineers, the number of students increases greatly, so the salaries drop and an increasing number cannot find jobs. As a consequence, the number of students declines rapidly and after a time salaries rise and so do job prospects. Then there is a scarcity of jobs and high pay and the old cycle starts again. Here seems to be a vital need for an over-all study of the employment opportunities in the various branches of engineering, brought down to the level of careful individual counselling.

b. The first years the young engineer spends in industry may need much more careful planning. Here there is much that can be learned from personnel administration in selection, interviewing, induction and on-the-job training. I want to elaborate on that in my third major consideration.

Clarifying the Implementation of Responsibilities

If you are considering the type of goals and responsibilities of engineering education which I outlined to you, how could they be implemented in college and in industry so as to bridge educational gaps? While much valuable thinking has been done to solve this problem, we do not yet possess the final answers but merely plans. Let me try to report to you some of the best thinking which I have found.

In *universities and colleges* I discern a trend toward the development of some type of curriculum like the following: First, much emphasis continues to be placed, of course, on technical education. In this there is a tendency toward a thorough learning and comprehension of basic principles. These principles are applied to cases to illustrate their working and to problems to develop the student's familiarity with and ability of tackling situations such as he is likely to find in industry later on.

Second, there is a trend toward the development of courses in economics and business subjects. Training in economics is designed to give the students tools that will help them in the analysis of general economic problems, to give them what a famous economist (Alfred Marshall) so felicitously called "an engine of thinking." Woven into economics is a knowledge of the fundamental principles of economic techniques such as accounting and costing, statistics, finance and marketing.

Third, a study may be made of the theory and practice of general administration. A study may be made of general administration in terms of organization, the optimum division of major functions, the delegation of responsibility and authority, decentralization, and

above all the coordination of technical and economic activities.

Finally, a broadening interest in cultural subjects might be emphasized. The performance of administrative activities requires articulation, the power of being understood and the power of influencing people to act. Technically that requires the ability to write reasonably brief and short reports and the ability to express oneself effectively. This competence would be greatly aided by a good knowledge of the best of our literature. More basically, a knowledge of the past is needed to understand the present and future and a knowledge of the mainsprings of men to undestand why people act the way they do.

Now let me turn briefly to the implementation of the goals of engineering education by the *practicing engineer in industry.*

You are familiar with the reports of various engineering committees finding considerable deficiencies in the training programs of industry. There appears to be a special weakness of guidance and development in smaller companies.

The practicing engineer spends much time and careful thought in getting maximum production from his machines. He tries to keep them in the best possible condition over a period of time. But the development of men is often not on a par. Such a development would not only pay handsome dividends in attracting better men, maintaining high morale, and in maximizing their contribution but this also seems to be a real human obligation to any young man entrusting his best years to industry.

Initially the practicing engineer could be of great aid in consulting with students on job prospects and in directing them into the right careers. This could be done by being available to students at the offices of the university or receiving them in their own company. Active work in the local engineering chapter and occasional lectures to groups of young engineers will also help in giving them a notion of what to work for and what to expect. The new service of the Engineers Council for Professional Development and the Educational Testing Service for administering aptitude tests of the Pre-Engineering Inventory and the Engineering Achievement Tests for engineering students may be another helpful step in career guidance. In the company itself there should be careful setting of standards and selection by the company's engineering staff, with a view to possible later promotion to top management. The new man needs thorough orientation. Next a formal training program, developed in line with opportunities, might be set up under the guidance of an engineering counsellor, who watches progress and smoothes out difficulties with supervision and production management. A top management official's personal interest in the young engineer would be a great additional spur. Regular checks and re-orientation of the program in line with needs are required. These formal and systematic training efforts we can neglect only at our peril. Outside lecturers, possibly even a shifting of routines and positions within the plant, might be used to improve competence.

Cooperative plans between the company and the local college which make it possible to have students work part-time in the company and supplement theoretical training, while both the practicing engineer and his charge might take continuation and refresher courses at the university, both in technical and general subjects have great possibilities. A recent study made by Walter Schmitter for the ASME found in the Middle West that "cooperation between industry and college in education was poor."* Yet internship by the university staff for 6 to 12 months has been found to be of great value to both parties.

Conclusion

Let me now sum up briefly: In dealing with this very difficult subject, I have

* Walter Schmitter, "Engineering Training," *Mechanical Engineering,* September, 1948, pp. 743–746.

made the following specific recommendations for practical action by the practicing engineer:

1. He should make a contribution by participating more frequently with the universities in formulating the goals of engineering education.
2. He should take more initiative in joint establishment of engineer-educator responsibilities.
3. He should recognize the increasing demand for and promote broader cultural training in engineering schools.
4. He should provide guidance and encouragement to the engineer-educator for the development of technical, social and personal engineer competence.
5. He should participate in setting up and continuing a study of employment prospects for various types of engineering.
6. He should personally counsel and advise young men on the problems of their occupational choice.
7. He should make available to his local engineering schools the facilities of his plant so that academic training can be simultaneously supplemented by practical experience.
8. He should carefully plan the selection, orientation and training of the young man on the job during his first years in practical engineering.
9. He should encourage the young engineer to pursue part-time, formal education at the local engineering school.
10. Above all, he should always encourage competence and maintain high morale.

These are some suggestions to implement the goals and the responsibilities of engineer-educators and the practicing engineer so as to bridge the educational gaps. But you, as representatives of the best thinking in engineering education, may want to look beyond engineering. I believe many of you already are and soon will be going beyond engineering. For an increasing number of your students already are or will be members of higher management.

There is a fundamental difference between engineers and managers. Engineers are predominantly doers, managers are those who "get things done through the efforts of other people."

Engineers work with things, managers with human beings. Engineers treat matter and materials, energy and elements, managers deal with intangibles and imponderables, with feelings and sentiments. Engineers can analyze, predict and measure with great accuracy, but managers can merely estimate. The one can make controlled experiments, the other has only general reasoning and experience to guide him. You can mould clay any way you want to, but you could not do that with human beings. Managers plan and control and that requires as much or more planning as a complex engineering problem. You might call it the human aspect of engineering. It requires at least two factors for success—organization and supervision. Organization is needed to establish cooperation, supervision to create good employee relations so as to accomplish the tasks of the business.

A good manager will introduce tolerance, patience, understanding of human nature as well as spiritual values in addition to technical perfection. That society then in which engineering and management, technical and human competence, are combined into an optimum, that will be the *Great Society.* What a challenge that is to the ingenuity of educators and practicing engineers to work out to the benefit of all!

ANNUAL MEETING
MICHIGAN STATE COLLEGE
East Lansing, Mich. **June 25-29, 1950**

Meeting Tomorrow's Needs*

By HARRY A. WINNE

Vice President, General Electric Co.

I suppose each of us here tonight is inherently an optimist or he would not be here—he fully expects a better world, broader opportunities, greater satisfactions tomorrow than he experienced today. But each of us also knows that those broader opportunities place upon him greater responsibilities, that "tomorrow" will bring with it still more complex problems, and more insistent demands for the solution of those problems, promptly and effectively, than ever before. For a group such as this, it seems to me that a large measure of our responsibility, and by the same token our opportunity, is to provide better education and better experience for the young people in our technical colleges, and in industry, on whom, after all, the achievement of that better tomorrow depends.

And, of course, you know that I am not thinking of tomorrow's problems solely, or even largely, in terms of better washing machines, or more efficient motors, or faster locomotives. Certainly such problems will exist, and our technological progress must continue. But we have pretty well demonstrated that we can solve our technical problems. We can build new and better machinery and we can do it at astonishing speed.

However, there are urgent problems in other areas, social and political particularly, which are far from solution, and to the solving of which we, as engineers, have devoted, I feel, very little honest effort, largely I suppose because of our preoccupation with our technical affairs. At least this is the excuse often given, but I wonder if a more honest reason would be that these other problems are more difficult, are incapable of solution by mathematical formulae. And yet they affect us and our works vitally.

In the meantime, others have often attempted to solve them for us, not by reason or fact but by intuition, hunch, or political expediency. We are beginning to see clearly demonstrated the fact that our industrial progress is even more affected by economic and political factors than by science and invention. It is therefore not only desirable for an individual engineer, but also imperative for the engineering profession as a whole to focus its attention upon such matters as these, to study the problems objectively, and to determine the most effective solutions.

Social Responsibilities of the Engineer

Here we are faced with a dilemma: most engineers and scientists who should be best equipped by training and experience to make a factual approach have had very little other than technical training. Conversely, those who have had training in the fields of politics and economics often seem to be unfamiliar with scientific or logical methods. From this condition, as well as the personal needs of the individual engineering graduate, has arisen the demand that the colleges should provide more so-called cultural education for engineering students.

* Presented at Mechanical Engineering Division Dinner, ASEE Meeting, Troy, N. Y., June 22, 1949.

The author wishes to acknowledge the very generous help in the preparation of this talk, given by Karl B. McEachron, Jr., Manager, Technical Education Division, General Electric Company, Schenectady, N. Y.

This situation is one not easily rectified. I think it has been brought forcefully to the attention of many broadly-thinking people by the writings on political or sociological matters of some of our distinguished scientists and engineers. Because these people have won renown in technical fields, a large part of the general public seems to accept as gospel their thoughts on any subject. Would that such confidence were always justified. Perhaps my own remarks need to be reviewed by you from this quite critical viewpoint.

It seems to me to be true that, while the fields of politics and sociology need attack in the same basic, fundamental way in which we are accustomed to approach our engineering problems, they are not at all readily amenable to this kind of study. The reason, of course, is that in these fields we are dealing with the reactions of human beings, which are not, and cannot well be, charted and tabulated in any handbooks.

So, we think we should like our coming generation of engineers to have a broader education! Whose responsibility is it to bring this about, and how is it to be done? Both engineers in industry and engineering college faculties are parts of the engineering profession and it is therefore the profession as a whole which has new educational needs and which at the same time must organize to meet those needs. Responsibility for engineering education is therefore a *professional* responsibility, one which every man who considers himself an engineer must share. Engineers in industry seem somewhat prone to overlook or neglect entirely this aspect of the professional estate in their pursuit of technical problems. Each of us owes to engineering education a debt which we can repay only by supporting and improving that process through which we were given a chance to become engineers, and I wonder how well we realize this, and how many of us act upon it?

There have been brought to my attention recently the results of financial campaigns carried on by two different colleges, one a strictly technical school, the other preponderantly a liberal arts institution. In the case of the technical college, the campaign is not going too well, support of alumni and students seeming to be rather half- (or less) hearted. The liberal arts college on the other hand is receiving most enthusiastic cooperation from students, alumni, and community. I cannot help but wonder whether the cultural background and training supplied by the latter institution is a factor influencing the feelings toward it.

Of course, financial support alone is by no means sufficient to insure improved education. The active, personal interest and participation of engineers in all positions, in industry as well as in the colleges, are essential to educational progress at all times.

It seems particularly necessary now that the colleges receive the support and guidance of the profession in attempting to meet the broader educational needs of the engineers of tomorrow.

The Social-Humanistic Stem

Engineering education, through this Society, has done more than simply to recognize the requirements of industry. In two separate committee reports, it has emphasized the importance of the so-called "social-humanistic stem," and has even gone so far as to suggest the portion of an engineering curriculum which should be set aside for such non-technical courses. The Report of the "Committee on Engineering Education after the War" recommended the following humanistic-social goal: the "development of the ability to read, write, and speak the English language effectively; to understand, analyze, and express the essentials of an economic, social, or humanistic situation or problem; and to appreciate its implications and relationships to the life and work of an engineer. There is also the goal of development of an adequate concept of the duties of citizenship in a democratic society; an acquaintanceship with the enduring ideas

and aspirations which men have evolved as guides to ethical and moral values; and an appreciation of cultural interests lying outside the field of engineering." The Committee further recommended that "the allotment (of time) to humanistic-social courses, not including drill courses in English Composition, be not less than one 3-credit course in each of the eight semesters, or approximately one-fifth of the entire (engineering) curriculum."

But the colleges have also done more than state objectives; they have, to a remarkable degree, in the five short years since this report was published, implemented the recommendations of this report. Large numbers have increased the courses devoted to social-humanistic studies. Others have concluded that what is needed is more emphasis on English, economics, psychology, etc., in the present technical courses, and I believe this is good. Still others have despaired of adding courses to the already crowded curriculum and have established the five-year program as the solution. But in one way or another, most colleges have made some positive response to the recommendations of these Society Committees.

In the teaching of the fundamentals of science and their application to physical problems, engineering educators have developed great skill and experience. You have carefully taught engineering students to look for the relation between cause and effect, to reason from the fundamentals behind this relationship what the results will be when a given set of conditions exists. It has been possible to prove to our satisfaction that a few fundamental principles will serve as a basis for technical study and investigation in a wide range of engineering fields.

However, in economic, social, or political areas, or, in short, where the actions of people as groups or as individuals are a major factor, the basic principles are much more obscure. The elapsed time between cause and effect is likely to be so great that it is difficult to recognize which effect goes with which cause. A complex of multiple causes and effects may be so intertwined that it is virtually impossible to separate one from the other. Great geographical distances may exist between the two.

And yet, while the man on the street professes little understanding of engineering and science, every soap-box orator claims to have his solution for the economic or political problems that perplex us. Many of us here tonight, I dare say, would not hesitate to express an opinion about what ought to be done with the Communists, yet few of us would be so prompt in diagnosing the trouble in a complicated piece of machinery we have never seen, and please believe me when I say that I am not implying that we should be classed with the soap-box orators.

The general public's lack of understanding of engineering fundamentals, and its general good sense in such matters, prevents any widespread attempt to substitute political edicts for scientific laws. Here and there attempts have been made, such as the state law—still in effect, I believe—that henceforth, in order to simplify calculations, the value of pi shall be an even 3 instead of 3.1416 + ! And even in such cases, it pretty quickly becomes clear that the law hasn't really changed the scientific fact. In spite of that, I judge from what I read in the newspapers that the Soviet government is adventuring in this realm at the present.

Attempts to Nullify Fundamental Economic Laws

But there is good evidence of the existence of widespread belief that in many other areas man-made laws can control, or alter, what may be classed as natural results. Witness our own government's efforts at controlling commodity prices and farm production, thus appearing to legislate out of existence the natural law of supply and demand. In my opinion time will prove the fallacy of such endeavors.

There unquestionably is an increasing tendency, which I think is increasingly dangerous, to look to government to solve our economic problems by law, to provide jobs, security, health, and what not —in other words, for us to evade our individual responsibilities. But ultimately we, as a nation of individuals, must accept our responsibilities as citizens, or face the consequences. If we drift—or speed—more and more toward state control of our every activity, more and more toward an omnipotent, but unfortunately not omniscient, government, each of us has a degree of individual responsibility for that —in my estimamation—very unfortunate course. And perhaps those of us here tonight have a proportionately large responsibility, because of the opportunities we have to instill in young people a realization of the need for understanding more about economics, more about politics, more about society in general, as well as for becoming capable engineers and scientists.

We need to seize these opportunities, to ensure that our young people have some foundation from which to judge whether or not ever-increasing governmental control of our normal activities is good or bad. Such control, especially if carried too far, can have a very stultifying effect on the business initiative which has brought our country to the forefront of world industry.

In this connection I want to quote from a report to the stockholders of the American Gas and Electric Company by Mr. Philip Sporn, President of the Company, at a recent meeting. Mr. Sporn had outlined a proposed development program for the company which will involve the expenditure of about $251,000,000 in the three year period 1949–1951. Then he goes on to say—

"We can be stopped. The system that we will develop to meet that will be perhaps almost double the size of our system as it is at the present time. And I see no basic difficulties of any kind to the realization of that. Yet there are a number of possible developments that may frustrate such growth and expansion. The few given below are those that seem to me to carry the greatest threat to realization of growth on and of our system.

"First, a possible breakdown in our social-economic system. This is the kind of thing that those who want to see the spread of collectivist ideas the world over not only predict but energetically work for. I do not believe that that will come, but if it should it most certainly would carry with it the defeat of ideas and plans of the kind I have been discussing.

"Again, there is the possibility of socialization of the electric industry. This, too, is being vigorously propagated by those who, while not willing to subject the country to the agonies accompanying a breakdown in the social-economic system, are still willing to push wedges of socialization into any phase of our economic system where the chance of splitting it off seems reasonably good. They do it under the guise of advancing the social welfare of the country, but that would be true only if social welfare and socialization were inevitably synonymous. However, mild as is the threat of socialization at the present time, I believe the threat will become aggravated if the industry does not do the job demanded of it by the times and by the needs of the country. It is because of this that we in American Gas have taken our responsibility so seriously over the last decade.

"It is in this latter connection that you as stockholders must also do your part. Each of you has an individual responsibility to the common good. Each of you has a large stake—basically it is the welfare of your country and, therefore, your own welfare as a citizen. On another level you have a stake as a stockholder in this and perhaps in other corporate enterprises. You should ponder on this great responsibility and avoid the passive attitude which I am afraid is altogether too common today, and use every proper influence within your power to arrest the many unhealthy trends away from the free enterprise system that has brought the general welfare of this country to the high level that we have today and which, if continued, with modifications, changes and improvements, can raise it to very much higher levels."

Mr. Sporn's remarks constitute additional evidence that American business

leaders fully realize that our system of individual enterprise can continue to exist only if we realize and assume individual responsibility.

Parenthetically, it seems to me we hear nowadays a lot of talk about "academic freedom." I feel emphasis is much needed on "academic responsibility."

Experience as a Background for Understanding

It is perhaps unfortunate that our engineering graduates cannot begin their careers with the experiences of a life time behind them, and yet I suppose this would take away from them most of the zest, and all of the anticipation, of living. What I am trying to say has been much better expressed by Sir Richard Livingstone in his essay "On Education," in these words: ". . . you cannot study *fruitfully* certain subjects, among them philosophy and politics, unless you know something of life. On the other hand there are subjects, such as mathematics, of which a boy or undergraduate is fully capable, even if he knows nothing outside the walls of his home, school or university. For whereas politics and ethics are concrete, mathematics is purely abstract and theoretical, and does not spring from life or need experience of life to illuminate or correct it."

That is, our young engineering graduates and students really need some "experience of life" as a background against which to view economics and social issues in proper perspective. Without such experience I suppose we cannot expect them to reach sound conclusions any more than the socialist with the two shirts. You will remember the socialist who, attempting to explain the glories of socialism to his skeptical friend who said, "You mean that if you had two cows and I had none, you would give me one?" "Yes, that's right." "And if you had two cars and I had none, you'd give me one?" "Yes, that's how it works." "And if you had two shirts and I had none, you'd give me one?" "Well now, wait a minute, don't go so fast. I've got two shirts!"

How we react to many of our social and economic problems is in large measure determined by our own individual experiences.

Obviously most students in college have had very little "experience of life," and what they have had probably bears little relation to what they will find in their future careers in industry and society. So it seems clear that education in the humanities is a problem which cannot be solved by the colleges exclusively. Industry, and more directly the engineering profession, needs to assume the responsibility for guiding and counseling the engineering graduate so that his understanding of the factors influencing social and economic trends will be enriched by his industrial experience. Most of us today would be better informed in these areas, better citizens, better employees, and better *professional* engineers if our earlier experiences had been as effectively used to develop our understanding and appreciation of the humanities as to develop our ability to solve technical problems. I feel that there is evidence in our technical societies, and in many industrial organizations, of an encouraging effort to bring about this better understanding.

What, then, should the colleges seek to develop in engineering students in this area if some "experience of life" is wellnigh essential to a true appreciation of the humanities? Must the job be left entirely to the post-collegiate period? I hardly think so, although there is a real danger in trying to insert in the engineering curriculum too strong an emphasis on non-technical courses. It seems to me that the aim of undergraduate education in these fields should be to "whet the appetite" for further study of economic and social areas beyond college, rather than to develop "experts" in social or political science. Illustrations of principle may be drawn from the personal experiences of the class, from extra-curricular activities, campus politics,

etc. The objective, as in all education, should be to lead young people to a more complete understanding, not to drive them.

Perspective and Professional Responsibility Needed

Somehow we must give the engineering graduate a proper perspective as to how important these subjects will eventually become to him personally, how much better fitted, even for a technical career, he will be with them, and how far short of a professional engineer he will fall if he fails to broaden his areas of understanding continuously.

And, we must endeavor to develop his sense of individual responsibility, responsibility to himself, to his family, to his country, to the world. Sometimes I fear that the atmosphere in our college classrooms is not particularly conducive to this development. Too often it seems that the teacher is taking the responsibility for forcing an education on the student, whereas the ideal should be for the student to feel responsible for taking full advantage of his opportunities to obtain an education. Of course, actually the good teacher *should* assume this burden, but I feel also that the good teacher can do this best by gradually leading the student to become conscious of his own responsibility.

I feel very strongly the importance of this development of the sense of responsibility of the individual. It seems to me that the social trends of our times tend to decrease rather than to develop this sense. While I am heartily in favor of adequate pension plans, for example, I doubt very much that the evident increasing influence of such factors on the young graduate in making his choice of employment is a healthy sign for our future. As has been said many times, the only security in which a young man should be interested, is security of opportunity.

If he lacks a real sense of his individual responsibility, I fear the engineering student will not be greatly interested in gaining an understanding of those factors outside his technical field which will have such far reaching effects on his future life and happiness. The extent to which we can develop interest among the engineering students in education for living, rather than simply education for earning a living, and can strengthen that interest as the engineering graduates gain experience in industry, will largely determine whether we achieve our educational goal—which, in the words of Eldridge Haynes, should be to help them "to think better than we have thought—to arouse their curiosity for knowledge beyond ours, to nourish a sense of social responsibility greater than we have shown, to inspire higher ethical standards of personal satisfaction than we have had, and to equip them to fashion better tools than we have used, to find the answers to problems we created but have not solved."

Licensing for the Engineering Profession*

By JOHN L. WADDLETON

Manager, Labor Section, Legal Division, Allis-Chalmers Manufacturing Company

The question of licensing for the engineering profession raises first the legal principle of the right to work, a right which has recently begotten considerable public attention.

Legal Aspects

The Fifth Amendment to our Federal Constitution provides in part that "no person shall be deprived of life, liberty or property without due process of law."

The Fourteenth Amendment to our Federal Constitution provides in part "nor shall any state deprive any person of life, liberty or property without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws."

These constitutional provisions have been interpreted by the courts down through the years as guaranteeing the right to work.

The interpretations have been summarized as follows:

"The right to earn a livelihood by following the ordinary occupations of life is protected by the Constitution. Such protection is particularly found in the guaranties of the Fourteenth Amendment. It has been said that the preservation of such right is the principal purpose for the Constitution itself and is of the very essence of the personal freedom and opportunity that it was the purpose of the Fourteenth Amendment to secure. The right is fundamental, natural, inherent, and inalienable and is one of the most sacred and most valuable rights of a citizen. A person's business, occupation, or calling is 'property' within the meaning of the constitutional provision as to due process of law and is also included in the right to liberty and the pursuit of happiness."

The principle of the right to work yields, however, in favor of a more important legal principle, namely, the right and duty of the government to use its police power to protect the general welfare and interests of the public.

The essence of the courts' decisions on this subject is:

"It is a universal rule that every business or occupation itself is subject to proper police regulations for the public interest. It logically follows that the right of every person to pursue a business, occupation, or profession is subject to the paramount right of the government as a part of its police power to impose such restrictions and regulations as the protection of the public may require."

To what extent may the government go in imposing licensing restrictions on the right to work, is the next question.

The courts have held that, under the police power, licensing restrictions may be imposed on any business or occupation in order to protect the public health, safety, comfort, or morals.

Where legislatures have imposed licensing on certain occupations in which special training is required to perform the work, the courts have sustained such legislation on the ground that the government may, through its police power, protect the public against the injuries that flow from incompetence and incapacity.

* Presented at the Industry-College Forum on "The Development of the Young Engineer" at the Annual Meeting, Rensselaer Polytechnic Institute, Troy, New York, June 20, 1949.

Furthermore, the courts have made it plain that unless it is arbitrary or extremely unreasonable, the judgment of the legislature will be sustained on the question of whether a certain business does or does not affect the public interest.

As a result, the right to work in numerous occupations has been limited by licensing procedures. Thus, a license is necessary 'most everywhere today to practice not only medicine, dentistry, nursing, and law, but also to engage in barbering or plumbing, or to operate a beauty parlor.

On the other hand, where licensing statutes have been struck down, the courts have usually pulled out all the stops on the "right to work" chord in writing the opinion supporting the decision.

In 1940, for example, the North Carolina Supreme Court in holding invalid a statute requiring a license for carrying on the business of dry cleaning, dyeing, and pressing clothing said:

> "Resort to the police power to exclude persons from an ordinary calling, finding justification only by the existence of a vague public interest, often amounting to no more than a doubtful social convenience, is collectivistic in principle, destructive to the historic values of these guaranties, and contrary to the genius of the people who did all that was humanly possible to secure them in a written constitution. We believe that they were intended to give to the individual a larger endowment of personal liberty than could be otherwise guaranteed; a greater opportunity for initiative, and the acquisition of those interests which make for responsible citizenship. . . .
>
> "We violate no precedent by referring to the important function these guaranties of personal liberty perform in determining the form and character of our government. They are not accidental or unrelated. They fall into the pattern of democracy upon which our institutions are founded. In no other part of the fundamental law is so well caught and held the aspiration for this sort of freedom. If those whose duty it is to uphold tradition falter in the task, these guaranties may be defeated temporarily, or permanently lost through obsolescence."

Does the practice of engineering meet the test of sufficiently affecting the public interest so as to warrant licensing of its practitioners?

As to legality, it is clear that the practice of engineering is so related to the general welfare that sound licensing procedures established by the legislatures will be sustained in the courts.

In the few instances where licensing procedures for engineers have been held invalid, the courts recognized that the profession was affected with the public interest and nullified the legislation on other grounds.

The real question is how, through the licensing procedure, to effectuate best the principles upon which it is based. In most cases the examining boards have broad discretionary power both as to granting licenses and as to enforcing the licensing provisions. Here again, the courts have not only sustained as constitutional these broad grants of discretionary authority, but have also sustained the boards in the exercise of that power.

Precautionary Measures

Therefore, the opportunity to make licensing effective is within the reach of the profession. For licensing to be effective, vigilance on the part of the profession is necessary in two main areas:

First, practicing by the incompetent and unethical, *both licensed and unlicensed,* must be prevented; and

Second, the conditions for the granting of licenses must be designed to bar *only* the incompetent and the unethical.

In the matter of preventing practice by the incompetent, the engineering profession has a much more difficult job than the medical and legal professions because there is not, in engineering as there is in the medical and legal fields, the channelization or focusing of the practice toward or at a particular point.

For example, one cannot practice any amount of law without finding it necessary to appear in the courts. As a result, denying the unlicensed access to the courts automatically prevents substantial

unlicensed law practice. Likewise, one cannot develop any amount of medical practice without issuing prescriptions or hospitalizing patients. Thus, denial of access to hospitals to and refusal to honor drug prescriptions of the unlicensed again automatically prevent unlicensed medical practice in those areas. This focusing of the practice of law and medicine also tends to expose any *licensed* practitioners who are, in fact, incompetent and unethical so that steps may be taken to revoke their licenses if necessary.

The engineering profession, lacking this advantage, must be all the more vigilant in preventing practice by the incompetent and unethical. It is understandable that a member of the profession will be reluctant to file a complaint or initiate proceedings that may result in another's losing his license. Nevertheless, if licensing is to be effective some technique therefore must be devised.

To do this disagreeable type of work, both the Medical and Bar Associations have standing committees. Important and constructive work has also been initiated by bar associations with non-legal groups whose work may at times border on or invade the practice of law. Examples of such groups are certified public accountants in certain tax work and life insurance salesmen in estate planning involving the drafting of wills and trusts and the application of inheritance taxes.

Through such efforts compacts have been reached with societies of these non-legal people specifying and prohibiting types of work which would constitute unauthorized practice of law.

Other problems, however, peculiar to the engineering profession arise in connection with this question of preventing practice by the incompetent. They might be classed as undesirable by-products of the process of limiting practice only to the licensed.

One results from the fact that the consulting engineer, in the practice of his profession, is usually a great deal more peripatetic than either the doctor or the lawyer and in his travels he may cross many state lines. He is confronted with the varying licensing laws in the states in which he operates.

The excellent work being done by the National Council of State Boards of Engineering Examiners in urging some degree of uniformity among the state licensing laws is about his only salvation from arbitrary deprivation of his right to work in such states. Since there will be a continuing need for such work, the profession must continue and increase its active support, particularly among the members of the legislatures at the times when unifying amendments are being considered.

The other area for vigilance is in determining the qualifications for license. This field includes such subjects as the accrediting of schools, grandfather clauses (the constitutionality of which has generally been upheld), the diploma privilege, the norms for determining good character, and the type of examinations to give where they are required.

It would hardly be appropriate for me, a non-engineer, to propose to solve such problems. That must be done within the profession. As a lawyer, however, I can point out that it is in this area that you have the discretionary power, almost absolute, to foreclose the right of individuals to work in the field of professional engineering. By the imposition of too arduous an examination, you may be denying some young man who has completed an engineering course of training in a good school the right to practice in the profession of his choice.

Let us recall what the North Carolina Court said in the cleaning and dyeing case:

"We violate no precedent by referring to the important function these guaranties of personal liberty perform in determining the form and character of our government. They are not accidental or unrelated. They fall into the pattern of democracy upon which our institutions are founded. In no other part of the fundamental law is so well caught and held the aspiration for this

sort of freedom. *If those whose duty it is to uphold tradition falter in the task, these guaranties may be defeated temporarily, or permanently lost through obsolescence.''*

A good example of what this judge was warning us against is found in my own field of labor law where it has been necessary to give some real thought to the problems created by certain types of interferences with the right to work that have been permitted to develop in our times. Two such types of interferenece are compulsory unionism and illegal picketing.

"Compulsory unionism" includes any form of agreement between an employer and his union, such as the closed shop, the all-union shop, or maintenance of membership, wherein the employer agrees to discharge any employe whom his union certifies is not a member in good standing. This, of course, gives the union the power to deprive any employe of his job by the simple act of stating that he is no longer a member in good standing.

Since the union alone determines the conditions necessary for its members to maintain good standing, it has, where it has gained compulsory unionism, the complete and arbitrary control of an employe's job—and mind you, no aspect of protection of the *public* welfare justifies it.

As to illegal picketing, it has been all too common in strikes for pickets to bar physically from a struck establishment anyone who desires to enter, be it an employe who prefers to work rather than strike, a customer, or a salesman. The actual purpose of violent, mass, and illegal picketing is, of course, to stop completely the operations of the struck employer and, more often than not, this purpose is actually accomplished in spite of the fact that it is crystal clear in the law that only peaceful picketing is legal.

"Peaceful picketing" is picketing which is confined to advising the public by printed and spoken word of the existence and reason for the strike. Its purpose is to *solicit, not require,* public support for the strike. The National Labor Relations Board, however, gradually drifted away from the recognition of this fact in its operations under the Wagner Act.

In case after case, the Board, while avowing that it did not condone violent picketing, ordered the reinstatement of strikers discharged because they were guilty of violence on the picket line. It became axiomatic, as a result, that "a little bit of violence could normally be expected in a strike." Over the same period, the general public, apparently misled by such official thinking, began to take for granted that unions had a right to close a struck operation and to prevent employes who desired to work in spite of the strike from doing so.

It can seriously be asked, therefore, whether in the field of labor law we have "faltered," as the North Carolina Supreme Court judge put it, to the extent where the guarantee of the right to work may be lost "through obsolescence." In the labor law area, the potential obsolescence brought about by the above-described types of interference with the right to work, namely, compulsory unionism and violent picketing, is readily apparent to discerning people.

Protection of Public Interest

In the case of licensing of engineers, however, the necessity to give consideration to the protection of the public interest provides the occasion where, in all good faith, actual but unwarranted deprivation of the right to work may unconsciously be brought about. In this connection, a statement from the November, 1947, meeting of the National Council of State Boards of Engineering Examiners in New York is food for thought.

That statement is:

"No longer will a national certificate be issued simply on the basis of graduation from an approved engineering school coupled with four years of satisfactory experience.

"Applicants must now have a record of ten years in the practice of engineering and

must pass a written examination approved by the Council.''

Unless it is true that such extension of the qualification for certification is necessary for the protection of the public—and, gentlemen, the answer to that question rests almost entirely in the sound judgment of your profession—such extension could well result in the deprivation of the right to work in the profession. In the same report, it is also noted that in the State of New York out of 40,000 applications for licenses, 20,000 were denied, and some of those unable to secure a license were practicing as engineers.

The question can be frankly asked, were all 20,000 whose applications were denied of such a degree of incompetence that their practice of the profession would have endangered the public interest?

In conclusion these points are respectfully posed for your consideration:

1. The practice of engineering is sufficiently affected with the public welfare to warrant proper licensing regulations restricting the right to work in the field;

2. Legislative grants of broad, discretionary authority to examining boards will be sustained in the courts;

3. The exercise of such discretionary power by the boards will also be sustained by the courts unless it is wholly arbitrary or unreasonable;

4. Therefore, the preservation of the right to work in the profession is to a large extent the responsibility of the profession itself;

5. The right to work as guaranteed by our Federal Constitution is one of the promises we have made to ourselves down through the years;

6. It is one of the promises we give to our children when we send them to engineering schools, to medical schools, and to law schools; and

7. Where the effectuation of that promise falls within the jurisdiction of your profession, let steps be taken that it not be "lost through obsolescence."

Integrating Sponsored Research into the University Research Program

By J. NEILS THOMPSON

Director, Off-Campus Research Center, The University of Texas

Introduction

Sponsored research was a significant activity at many universities during the recent war. It was an effective method of increasing much needed research activities. The success of most of the war research programs resulted in a stimulus for the continuation of an extensive program of sponsored research now being carried on by the Federal Government. During the war very little attention was given to integrating sponsored research into the programs of universities because large research divisions were established and most of the scientists were spending all of their time on research. To operate an efficient, economical, and, at the same time, a successful program during peace time is difficult. The successful integration of sponsored research into the universities activities is important because sponsored research can be one of the most effective means of training research scientists.

Without research scientists, the universities and colleges cannot train and develop research scientists. The best way to attract scientists to our campuses is to have well organized research programs and to have the mechanisms for developing such programs. John R. Steelman's report to President Truman, entitled "Manpower for Research," presents very vividly the importance of training research scientists. The following pertinent excerpts are taken from a section, "The Crisis of Science in the United States."

"The indispensable resource for progress in science is an ample supply of highly trained scientists and technicians. As a Nation, we face serious shortages in this field.

"Other resources for scientific work—the funds, facilities, and equipment—can be supplied within a relatively brief time. Increasing our supply of scientists is a task that cannot be performed overnight. A highly skilled and productive worker in research and development laboratories can be developed only by years of rigorous and intensive training.

"At present, we have only a limited number of such experts. This puts a ceiling on the amount of scientific effort possible today. Large expansions of our national program will become possible only as more scientists are trained."

A Cooperative Research Agency

The traditional teaching or line departments, such as chemistry, electrical engineering, government, etc., of most schools are charged with both teaching and research responsibilities. The emphasis on research varies from school to school and even from department to department in the same school. Within the administrative structure of most schools there are numerous services supporting the teaching functions of the departments. In order to fulfill research responsibilities, departments need a corresponding support necessary to develop their research programs. It should be the responsibility of the department to see that it has a research program but frequently this activity lags because of the

lack of services to enable the department to develop adequate programs. It is highly desirable, therefore, to have a research service agency which would cooperate with departments in the development of their research programs. It should be a cooperating agency which will develop as much coordination of research programs as is beneficial for cooperating departments or groups as a whole. Coordination does not mean supervision or dictation, but rather means scheduling aids and functions such that the research activities of the university will be benefited.

Most progressive universities require each staff member to perform both teaching and research. There are individuals who are primarily interested in research who are given opportunity to concentrate on research while those primarily interested in teaching are able to devote most of their time to teaching. It is the department's responsibility to see that this teaching and research are properly integrated within the department. A research agency working very closely with a department can perform services which will aid the development of a successful research program in a department. Although the responsibility for research activities is charged to the departments, the graduate schools of most universities have a vital interest in research, because it is a significant part of scholarly attainments and instruction. It is very necessary, therefore, that the research activities also be coordinated with the program of the graduate school.

The responsibilities of a cooperative research agency will vary from one institution to another and will depend upon a number of local factors and conditions. The following functions are some of those that are in greatest need in most universities.

1. Maintain a continuous survey of needs of departments and research groups.

2. Plan and coordinate the utilization of equipment and space specifically set aside for research agencies.

3. Plan and develop programs to increase facilities for research.

4. Provide staff for detailed administrative functions associated with research.

5. Develop and coordinate the organization of research groups which involve several teaching departments or other research groups.

6. Aid and coordinate participating groups in the development of research sponsors.

7. Cooperate with the administration in establishing policies that will enable rapid negotiation of contracts, ready commitments to potential sponsors, and preparation of research proposals.

8. Cooperate with the administration in the development of uniform, suitable, and adequate patent policies.

9. Establish and administer such centralized services as would be economical for the research groups as a whole.

10. Work closely with news services in accurately reporting research attainments.

In only a few institutions are these functions being carried on by a single agency. These functions are so related that to omit any phase of this activity will tend to minimize the accomplishments that would otherwise be possible. It is the writer's opinion that, with the opportunities available today, any university that coordinates these functions with a strong emphasis on cooperation will develop successful research programs.

Relationships Between Research and Teaching

In the development of a program to serve a university, it is very essential that the agency have a clear picture of the needs and the potential research facilities and personnel of a department. There must be a close relationship and contact between the research agency and the teaching departments if this information is to be accurately known. Opportunities develop suddenly, and unless some agency knows the university's needs, opportunities may be lost.

If it is at all possible certain basic equipment and space should be specifically set aside for research. Since the war some schools have had opportunities to acquire equipment and facilities which have been designated for research. The research activities of a large institution vary from time to time; therefore, with the changing emphasis, it is desirable that certain equipment and space be reassigned in order to secure the greatest benefit. The success of the coordination of utilization will depend upon the close relationship between the research agency and the research groups concerned.

There are certain detailed administrative functions which frequently deter faculty members and departments from entering research programs because of the "red tape" involved. The problem of providing stenographic, purchasing, accounting and legal services for small research programs frequently prevents the development of minor research contracts. With provisions for an agency that will perform these services, faculty members will frequently be encouraged to the extent that they will perform highly significant and important research, whereas, they might otherwise have the attitude that "it is more trouble than it is worth." Collectively, these problems are simplified within a group that knows how to handle them, but individually they are nuisances.

Frequently, opportunities for sponsored research are missed because they involve more than one field and no one department desires to take the responsibility of organizing the program. Coordination and development of organizations can best be performed by an agency definitely charged with the responsibility. Research organizations should be kept very flexible in order to adjust readily to the wide variety of research that is likely to come to a university. University research laboratories cannot be organized in the same manner as industrial or government research laboratories because the scope and the purpose for performing research differ.

One of the most important functions of a research agency is the aiding and coordinating of research groups in the development of sponsors. This is not an easy task and cannot be done on a simple promotional basis. The development of sponsors requires many different approaches and each case must be treated separately. The best contact with a prospective sponsor is through someone acquainted with that sponsor. It has been found, in dealing with various departments of the Federal Government, that contacts should be made by the scientific personnel in the field of research being considered. In many instances where the contacts have been made by laymen and "high-powered" promotional men, the proposals have failed even though they had considerable merit. In cooperation with the department concerned, the research agency should determine the best approach in each case and then provide the funds and other aids necessary for such contacts.

Contract Policies

Contract policies are one of the headaches of sponsored research and it will continue to be a difficult problem because each contract will have slightly different implications insofar as the educational program of the university is concerned. It is very difficult to work out standard contract forms for all research programs. This research agency should cooperate with the university administration in establishing policies that will enable rapid negotiation of contracts, ready commitments to interested sponsors, and expeditious formulation of research proposals. Frequently, research contracts are not consummated because too much time is required to clear them with university administrations.

It is not possible to establish a single patent policy that will cover all cases. The best patent policy for a particular university might be the poorest for another. There are numerous aspects to this particular problem, and it is not possible to present the details in this discus-

sion; but it must be emphasized that the solution is not simple and requires careful consideration by each institution. There are certain basic principles that can be established by an institution which will enable easy and rapid determination of the policy applicable to a particular case, but every case should be examined separately because an adequate patent policy is an important part in the encouragement of faculty members to participate in research. An equitable policy, in many instances, will prompt an outstanding scientist to come to an institution.

Research laboratories have certain common needs that a centralized service group can frequently perform efficiently and economically. These services can pay for themselves many times and will reduce overheads that are sometimes serious problems. It is not possible to list the services that could be centralized in every case. Some that frequently can be centralized include a glass blowing shop, an instrumentation shop, a central equipment and materials stock room, a reproduction service, etc.

One of the most effective mediums for developing research sponsors is the establishment of a reputation of accomplishments. Insofar as the scientific fields are concerned, scientists with their writings have publications which provide a certain outlet. However, it is very important that the public knows of a good reputation. This can be of inestimable value not only to the research programs of a university, but to its other activities. Therefore, it is very important that some agency cooperate with the news services in the accurate reporting of attainments.

Administrative Location

A research agency can be established either within or outside of the administrative structure of a university. There are many advantages in an external organization such as: making arrangements for purchasing of equipment for special scientific purposes, providing more adequate coverage of travel expenses, enabling less complicated patent policies, and formulating contracts which simplify negotiations, etc. The problem of supporting financially an independent research organization is simple during good times, but difficult during depressions. There are some schools that are able to support financially independent non-university connected research programs, but these are private schools and they do not have to be concerned with legislative appropriations as are tax-supported institutions.

The justification for a research organization, particularly in a tax-supported institution, lies in the benefits accruing to the educational program, students, and faculty. An internal organization is more likely to support the educational program of the university, because the educational policies and the research policies are under one administration. A research agency should be a supporting agency to the research responsibility of departments. It is believed that over a long period of time an organization established inside the university administration is more likely to maintain harmony and cooperation with departments than an external organization.

Properly directed and coordinated, either location of a research agency can be successful. Of prime importance, however, is an aggressive and cooperative operation. It cannot wait for a department or individual to come to it for help; many will not come. It must anticipate needs and be ready and willing to support those that desire to perform research. Research activity is a fundamental part of the university educational program and it needs the full attention of a good organization.

Construction and Analysis of Achievement Tests

By D. E. McFARLAND

Assistant Professor of Personnel Relations, Michigan College of Mining and Technology

A commonplace assumption regarding the professional responsibilities of the practicing engineer is that he must devote considerable effort to the development and maintenance of his tools and equipment. It is also assumed that teachers are acquainted with systematic procedures for evaluating the work of their students. Thus the teacher of engineers, particularly if he also is an engineer, has a dual reason for sharpening the instruments he uses to measure achievement.

Despite the pervasiveness of the foregoing assumptions, the sharpening process has been largely neglected not only by teachers of engineering subjects but by teachers generally. This condition exists partly because of the teacher's heavy work schedule, and partly because of the inertia which binds teachers closely to familiar routines. After all, a teacher *can* get by without evaluating his testing procedures; there is little likelihood that anyone will do his checking for him as long as the tests themselves have the outward appearance of respectability. It is dangerous, however, to assume that any test a teacher writes, however carefully, will automatically be a good measuring instrument. It is folly of an even lower order to assume that tests furnished by the publishers or authors of textbooks, or the vendors of "standardized" tests can provide adequate testing materials unless they are checked with reference to the specific conditions under which they are to be used.

Every teacher can improve the quality of his achievement tests by systematic attention to simple principles of statistical analysis. Although standard works in statistics [1] and testing [2] contain many methods which can be used for evaluating tests, the methods of analysis found most satisfactory by the writer will be described. Since the relative merits of the so-called "essay" and "objective" type tests are beyond the scope of this paper, the discussion will center upon tests built around the short-answer, objective type test item.

The Nature of Tests

The ability to evaluate tests requires a knowledge of the fundamental concepts of testing. Among these concepts the following are of prime importance:

1. *Tests are measures.* A test may be viewed either as a measuring instrument or a teaching device. The achievement tests used by the classroom teacher will ordinarily serve both purposes concurrently. As a measuring device, a test indicates the relative degrees of achievement of students; as a teaching device, a test provides both teacher and student with information about areas of weakness in teaching and learning. Although both purposes of tests command recognition, the measuring instrument concept of a test must predominate in its construction as well as in its evaluation. Achievement tests must be evaluated ac-

[1] A good standard work in statistics is Croxton, F. E., and Cowden, D. J., "Applied General Statistics," Prentice-Hall, Inc., New York, 1946.

[2] An outstanding recent work on achievement testing is Adkins, Dorothy C., "Construction and Analysis of Achievement Test," U. S. Government Printing Office, Washington, D. C., 1947.

cording to their primary purpose: in terms of their ability to yield reliable measures of student accomplishment.

If one knows what he wants to measure, it can be measured. This implies that in order to write good tests, the teacher himself must be thoroughly conversant with the material of the field tested. To write good tests a teacher needs a comprehensive, over-all familiarity with the subject. He must understand the forest despite its many trees. This postulation may seem obvious—yet it is precisely the handicap faced by the young and inexperienced teacher in the early years of his work.

Not only must the teacher know his subject matter well, but he must also plan his objectives so thoroughly that he can devise tests to measure the extent to which his objectives are accomplished. For example, multiple-choice, matching and completion-type test items measure the recognition aspect of memory. On the other hand, completion questions, direct questions, or essay-discussion questions require the student to recall knowledge. Obviously recall is more difficult for students than recognition. It is essential that the teacher consider his testing situation in the light of these psychological factors, and adapt his selection of test items to the kind of learning situations he has set up.

In this connection it is also of interest to note that experiments show that students prepare for tests more thoroughly and learn more effectively if they are told in advance not only whether the test is to be an objective or subjective type, but also what types of items will make up the bulk of the test.

2. *Tests are samples.* However complete the teacher's knowledge of the subject, and however great his ability to impart his knowledge to others, he will not be able to transmit the subject matter to students in its entirety, nor equally to individual students. Similarly, it will not be possible to reveal by tests the full learning accomplishments of students. The course work can only be sampled by a careful selection of test items.

Sampling is essentially a statistical process. The sample must satisfy two requirements: it must be representative, and it must be adequate. Representativeness is a qualitative aspect of testing which depends on the judgment and skill of the teacher, who must be certain to select items that represent all of the significant areas of subject matter, according them their approximate relative weights. The items must also be representative of all degrees of difficulty within the subject matter. Determining the size of the sample can be approached mathematically. This will be shown below.

3. *Tests are not the sole criterion.* Regardless of the degree of accuracy that can be built into a test, there is no absolute, precise way in which accomplishment may be measured. The student's attitude, environmental factors, personality, physical condition, *ad infinitum,* are complicating factors which affect the evaluation of a student's work willy-nilly. One must not be misled by the mathematical precision in which tests results are commonly expressed.

How to Evaluate a Test

Two criteria must be satisfied for a test to be an adequate measuring instrument. A test must possess both validity and reliability. Validity is present in a test if it measures successfully the thing it purports to measure. To evaluate the validity of a test it is necessary to select an outside criterion with which to compare the test scores. The criterion selected may be success on a particular job, or the successful performance of students receiving high scores when they are confronted with work or problems depending heavily on the subject matter of the test. Thus if a test used in selecting lathe operators is a valid one, those who earn high test scores would tend to be those attaining success as lathe operators. Validity is hard to establish for achievement tests because of

the difficulty of selecting criteria for comparison. The difficulty of measuring validity is partly offset, however, by the fact that if reliability is high, validity also tends to be high. It can readily be seen that the teacher derives maximum benefits from devoting his efforts to evaluating and improving the reliability of his tests. This is particularly true when tests are to be used repeatedly, but even where tests are used only once the reliability demonstrations help a teacher learn how to construct reliable items.

The term reliability refers to the ability of a test to secure consistent results. A test which secures erratic and unpredictable results whenever it is used is clearly undesirable. The problem of measuring the reliability of a test may be approached in three ways: (1) the retest method, (2) the use of two different forms of the same test, and (3) a comparison of two halves of the same test.

In the retest method the test is given again to the same group. Assuming little or no change in learning in the interim, high reliability would be indicated if each student receives approximately the same score on the second test as he got on the first. This method is impractical because class time is too limited to utilize in forms of experimentation where the teacher is the principle beneficiary. Moreover the assumption that no intervening learning takes place cannot easily be safeguarded. Intervening learning will not damage the results seriously, however, if the retest is made within a short period of time.

If two forms of a test are given to an individual he should get approximately the same score on each test, if no influential intervening activities occur. The scores on comparable items should also show close correspondence. Here again the time required of students and teacher (in writing the second form) is often prohibitive.

Comparing the two halves the same test eliminates some disadvantages of the first two methods, but it requires an investment of from one to two hours of a teacher's time—less if a stenographer or a student assistant is available. The writer has found that a student who is displeased with a test is often willing to help a teacher find out whether it was a good one. The correlation techniques employed are such that any student in personnel management, psychology or economic statistics can reasonably be expected to learn them as a requirement of those courses.

The following examples, adapted from Yoder, illustrate the application of simple correlation techniques to the problem of comparing the two halves of a test.[3] The manner in which the test is divided is not important as long as each half is representative of the test as a whole and the items in each half are comparable as to difficulty. Yoder suggests that where the number of questions is large, representativeness can be readily achieved by comparing scores on odd-numbered items with the scores on even-numbered items.[4] The first step is to tabulate for each paper the total odd-

TABULATION SHEET[5]

Paper No.	Score on Odd Items X	Score on Even Items Y	X^2	Y^2	XY
1	2	4	4	16	8
2	4	5	16	25	20
3	9	10	81	100	90
4	6	8	36	64	48
5	8	12	64	144	96
6	12	12	144	144	144
5	6	8	36	64	48
8	10	8	100	64	80
9	12	10	144	100	120
10	9	6	81	36	54
Totals	78	83	706	757	708

[3] Yoder, Dale, "Personnel Management and Labor Relations," Prentice-Hall Company, N. Y., 1948, pp. 280–283.

[4] *Ibid.*, p. 280.

[5] The figures in this tabulation are actual scores taken from randomly selected test papers of a colleague's class in economics.

numbered items (X), and the total even-numbered items (Y). X^2 and Y^2 and XY are then tabulated, and the summation of each column obtained.

When the tabulations have been completed and the summations obtained, the following formulas may be applied:

$$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{N} = 706 - 608 = 98,$$

$$\Sigma y^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{N} = 757 - 689 = 68,$$

$$\Sigma xy = \Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N} = 708 - 647 = 61,$$

$$\sigma x = \sqrt{\frac{\Sigma x^2}{N}} = \sqrt{\frac{98}{10}} = \sqrt{9.8},$$

$$\sigma y = \sqrt{\frac{y^2}{N}} = \sqrt{\frac{68}{10}} = \sqrt{6.8},$$

$$r = \frac{\Sigma xy}{N\sigma x \sigma y} = \frac{61}{10\sqrt{9.8 \times 6.8}} = \frac{61}{81.6} = .748,$$

$$r_t = \frac{2r}{1+r} = \frac{1.496}{1.748} = 0.856.$$

In the above procedure, N is the number of students whose papers are used in the investigation, and r represents the coefficient of correlation for one-half of the test. The reliability coefficient for the whole test is found by correcting r to obtain r_t. If the reliability coefficient is less than 0.80, a test cannot be considered sufficiently reliable.

The split-half method of obtaining reliability coefficients is frequently criticized because it is possible for the result to vary depending upon how the test is split. This difficulty also exists in the correlation of two forms of the same test. The real problem is of course to divide the test into *equivalent* halves. For a number of years the Kuder-Richardson formulas have been used to escape the disadvantages of the split-half method. Like the split-half method, these formulas require only one form of the test, and they possess the advantage of providing unique values as coefficients of reliability. A further advantage of the Kuder-Richardson formulas is that should their rigid assumptions not be fulfilled, the resulting coefficient tends to yield a low estimate. Since a failure to observe the assumptions of the split-half method will also result in underestimation, the writer prefers to use the simpler split-half method.[6]

Increasing the Reliability of a Test

Two procedures are available for increasing the reliability of a test: (a) increase the number of items comprising the test, (b) critically examine each item with respect to its effectiveness in discriminating between the good and the poor students. With respect to the first method, any objective type test tends to be unreliable when only a relatively small number of items are included. The second method involves a process known as item analysis.

1. *Length of a test.* Since the amount of time available for testing is ordinarily limited to the duration of a class period or other allotted unit of time, it is necessary that the number and difficulty of test items be set at a point where the majority of the class can finish the work at a reasonable pace. Although there are occasions where it is desirable (and even realistic) to train students to work under speed and pressure, a measuring process is not the wisest method of effectuating such training. What is wanted in achievement testing is a balanced approach to the problem of quality and quantity of achievement.

While the maximum length of a test is determined by what the students can reasonably accomplish in the given time, the minimum length is governed by the likelihood of destroying the test's reliability

[6] For the above critical evaluation of the split-half method the writer is largely indebted to Adkins, *op. cit.*, pp. 148–154. This reference contains the Kuder-Richardson formulas, but does not present their derivation.

through failure to include enough test items. As a matter of practical experience the writer has found that a one-hour test can be built successfully on 70 to 80 well worded true-false questions, or from 50 to 60 mulitiple-choice questions. The minimum number of true-false questions under any circumstances is 50, and the minimum number of multiple choice questions would be 40. If matching and fill-in exercises are to be included, it is desirable to reduce the other kinds of questions to a figure somewhere near the minimum. While most teachers know approximately how much work their students can be expected to do in an hour, there is frequently a temptation to tack on a dozen or so true-false or completion questions merely to pad out the test. By measuring the reliability of several tests a teacher can demonstrate to himself the weaknesses of this procedure.

A reliability coefficient of less than 0.80 can be raised to the desired standard by increasing the length of the test according to the following formula:

$$r_x = \frac{Nr_t}{1+(N-1)r_t},$$

where r_x is the factor by which the present length of the test must be multiplied, and r_t is the coefficient of reliability of the test.

Suppose it is desired to raise a test having a reliability coefficient of 0.72 to the minimum, 0.80. By substitution,

$$.80 = \frac{N \times .72}{1+(N-1).72} = \frac{.72N}{1+72N-.72},$$

$$.80(1-72N-.72) = .72N,$$

$$.80-58N-58 = .72N,$$

$$22 = .14N,$$

$$N = 1.57.$$

If the additional items are equal in selective value to those already included, the desired reliability can be obtained by increasing the test to 1.57 times its present length.

2. *Item Analysis.* The purpose of item analysis is to evaluate each test item with respect to its ability to distinguish between the better and poorer students. If an item is missed by most of the high-scoring students and answered correctly by most of the low-scoring students, it is obvious that the item was unsuccessful in dividing the group according to learning achievement.

While there are several ways to analyze each question, one of the simplest methods is as follows:

1. For each item divide the papers into two groups, those answered correctly and those answered incorrectly.
2. Note the average of total grades for each group.
3. For the reliable questions, the average score of those answering the question correctly should be appreciably higher than that of those who answered incorrectly. Questions for which the reverse is true, or for which the results are nearly equal, should be revised or eliminated. Reliable items can be incorporated into a test file for purposes of convenient reference.

Summary

1. The principal argument of this paper is that a teacher should devote specific and analytical attention to the evaluation of his measuring devices. The "lack-of-time" counter argument does not appear to be convincing.

2. The nature and purposes of achievement testing were reviewed in order to provide a systematic basis for the statistical analysis of achievement tests. Although one's philosophy and practice may not in all respects agree with this analysis, there remains sufficient flexibility in available statistical material to enable any teacher to develop his own evaluation devices.

3. Although the Kuder-Richardson formulas are in some respects superior to the split-half correlation methods presented, the writer prefers the split-half method because of their simplicity and because, like the Kuder-Richardson formulas, an underestimate will result from a departure from its basic assumptions.

4. Two methods of increasing a test's reliability were discussed: increasing the length of the test, and refining the individual test items after isolating those of low reliability by item analysis.

5. The methods described and conclusions reached in this paper are in no sense considered exhaustive or final. Rather, it is hoped that the reader will be stimulated and encouraged to investigate the problem of achievement testing, and to work out systematic methods of evaluating tests.

College Notes

Robert E. Steimke has been appointed Director of the School of Civil Engineering at the **Georgia Institute of Technology**, effective September 1. He was formerly Professor of Sanitary Engineering at the Pennsylvania State College.

Preparatory Training in France for the Degree of Doctor of Engineering*

By OLEG I. YADOFF

Professor, Research Associate, Sorbonne, Columbia University

The organization of higher technical education in France is indubitably known to many of those present at this Annual Meeting of The American Society for Engineering Education. We had the pleasure to see in France many American youths training for engineering activities in French engineering schools; many of us Frenchmen were taught in American universities. Thus, we mutually have a general impression of each other. Today, as our president Dr. Gaston Varlan has just expressed, my role is to acquaint The American Society for Engineering Education with the educational structure existing in France so far as it concerns the degree of doctor.

Types of Engineering Schools

It is interesting to consider the administrative distribution of our French engineering schools. All schools are divided into five groups. The first group includes Government-established schools which grant engineering diplomas. The second group embraces Government-recognized schools granting such diplomas. Strictly speaking, so far as the quality of training and the educational requirements are concerned, there is no difference between these two groups. Administratively, the first group is governed by a special department of the Ministry of National Education, called Direction Générale Technique (General Technical Department). At the head of this department there is a Directeur General de l'Enseignement Technique (General Director of Technical Studies). The second group is comprised principally of schools established by various universities. Here we can show a certain paradox: all universities in France are Government-controlled, but the schools established by them have a certain special half-way regime, and are for the most part called Institutes. We can obtain a logical explanation by recalling that such engineering schools-institutes were established at the universities depending on local industrial conditions and needs. These Institutes had an immediate material aid from local industrialists, and were developed and equipped in direct dependence on the progress of the industry itself. Their structure corresponds fully to American structure. The control of the schools-institutes in this second group is wholly entrusted to the universities, in whose names the diplomas are issued.

The third group is comprised of the higher technical schools, established independently of the universities but recognized by the Government and empowered officially to grant engineering diplomas under Government sanction.

The fourth group comprises schools organized also through private initiative and granting diplomas which are regarded as equivalent with the diplomas recognized by the Government.

Finally, the fifth group embraces all private engineering schools recognized by a special commission whose aim is a definition of a qualifying title of engineer.

* Presented before the International-Night Assembly at the Annual Meeting, Troy, N. Y., June 22, 1949.

To resume, we can say that all diplomas granted by the above mentioned schools confer the right to call oneself a graduate engineer (ingénieur-diplômé).

This division into groups is purely administrative and, essentially, none of these five groups has any special privileges.

New Group of Schools Instituted

A recent ministerial decree, in the preparation of which our distinguished colleague Dr. Gaston Varlan took a particular part, has created an entirely separate special group of engineering schools, whose educational standards are recognized to be fully qualified to permit an independent right of continuing one's higher education along the lines of personal research which may lead the student to the award of the degree of Ph.D. in engineering (Ingenieur-Docteur).

For all other above mentioned schools the decree presupposes supplementary training requiring attendance and examinations under the scientific faculties of French universities, in stated theoretical and applied sciences. Such supplementary training is in a sense extra-curricular and usually requires an additional two years.

As a corollary to such supplementary university training, there is in Paris Ecole Supérieure de Perfectionnement Industriel (University of Paris; "Livret de l'Etudiant," p. 386. France), whose aim is to supply a special extra-curricular activity in the realm of scientific and technical investigations directly connected with improvements and progress of industry. The professors of this Ecole Supérieure de Perfectionnement Industriel are simultaneously those professors of Sorbonne who are entrusted by the Ministry and the University with scientific supervision of the doctorates for the degree of Engineer-Doctor.

Thus, it follows that there are three different paths along which one can approach the training for the degree of Engineer-Doctor.

The degree of Engineer-Doctor itself, in American nomenclature and accepted meaning corresponds, as is known, to the American degree of Doctor of Philosophy (Ph.D.). This degree is governmental, and analogously with Government degrees of Doctor of Science (in mathematics and physics), the diploma is granted in the name of the Minister of National Education and over his signature and seal. Officially, this degree is the highest granted by the French Government in the realm of engineering education. Consequently, the diploma of Engineer-Doctor confers on its possessor all rights to practice the engineering trade in governmental and industrial establishments, as well as the right of professorial instruction in all higher engineering schools.

Requirements For Degree

Independently of the above mentioned training, the decree, presupposes two years of personal work of the candidate, who must develop and investigate a special original problem, bordering on discovery, which would directly connect science and industry into one whole. Such scientific and technical research is conducted in all specialties; civil engineering, electricity and radio, mechanics, mining, metallurgy, and chemistry. The theses submitted on such personal work have approximately the same character as the theses of large American universities.

The university assigns a second thesis of an exclusively eruditional character; in the main, there is offered an analytical development of some problem connected with recent discoveries and requires presentation before the jury of the student's critical considerations.

The preparation of the first, i.e., the basic thesis, deals mainly with personal experimental investigations. These investigations are conducted principally in the university laboratories under the supervision and guidance of a professor assigned by the dean.

Engineers who have already received practical industrial experience are very

often accepted for training for their doctorate. Their practical experience may cover several years, and, postulating a future doctorate, the engineer frequently occupies a major executive post in the industry. In such cases the dean, with the consent of the Council of Professors, may permit the aspirant to conduct his research not in a university, but in one of the generally recognized public laboratories, in a governmental or industrial undertaking. Nevertheless, the aspirant must remain directly under the guidance of a professor appointed for that purpose, to whom he must make periodic reports. These reports are transmitted by the professor, together with his notations, to the dean, who in turn transmits them to a special Ministerial Commission. In this manner there is obtained a strict and precise control of the scientific conduct of the work, as well as its industrial content. Sometimes the investigative work may have a separate special character, in which case there is added to the professorial jury, with the dean's permission, an engineer-specialist of recognized attainments in the problem involved. For the main part, the opinion of such a specialist is consultative; for him to have the right of vote it is essential that he himself possess the title of doctor.

The title of engineer-doctor was established in France in 1923, principally as a result of the efforts of Prof. G. Koenigs and the famous French engineer and scientist André Blondel (recently, to express the maximum recognition of the memory of this great scientist and engineer, the French Government issued a special postage stamp for foreign mails commemorating the Société Française des Electriciens, Comité André Blondel; and established the Blondel medal which is awarded for outstanding work in electrotechnics). By a new decree of 1931, the establishment of the degree of engineer-doctor was considerably expanded and finally assumed the form of the highest degree in engineering education as a result of the initiative of Dr. Gaston Varlan, who has been re-elected over several years as president of Association des Ingenieurs-Docteurs de France.

This Association des Ingenieurs-Docteurs de France, which I have the honor and the pleasure of representing in the U. S. A., plays a major role in the organization of educational facilities for engineers-doctors. Members of the Association continue with all their powers to interest themselves in the progress of science and in rendering aid to their future colleagues, the candidates for the doctorate. In this manner it became possible to establish a large number of scholarships. The Government met us half way by creating a considerable number of governmental scholarships.

Distinguished Awards of the Association

For the encouragement of the sciences, the Association des Ingenieurs-Docteurs de France awards annually an honorary medal to the candidate whose thesis was adjudged to be most outstanding. One medal, which received the name of the Gold Grand Medal, is awarded once a year to an engineer-doctor or to a foreign scientist maintaining a connection with the French Engineers-Doctors, for especially important services demonstrated by his scientific or industrial work of world-wide scope. Actually, these medals are awarded by a special commission which consists of famous professors of Sorbonne and of members of the French Academy of Sciences.

We, the French representatives, Dr. Gaston Varlan, Prof. General Max Jacobson, and I, observe with great pleasure here in the U. S. A. a wide development of scientific and technical research laboratories. It seems to us that there is no field to which your American scientific and technical world does not pay attention.

Nevertheless, there are certain special problems whose solution could be most useful, where the work could be conducted in our universities. As an example I could

cite the science of wave mechanics and the application of its principles to special scientific and technical investigations as well as in the engineering profession. I take the liberty to express my assurance that our entire scientific and professorial world would be most happy to render all friendly aid possible to each American engineer desirous of becoming acquainted with French methods of instruction and scientific investigations.

And now, in the name of my numerous colleagues, and Professors Varlan and Jacobson here present, I may say boldly and confidently: Welcome, we shall be truly glad to see you.

Memorial

WALTER L. HUGHES

Walter L. Hughes died very suddenly on November 26, 1949, at his home in Boston, Massachusetts. Mr. Hughes was born in Trenton, New Jersey, and graduated from Princeton University in 1911. He majored in the field of Chemistry.

He was at one time Director of Education in the United States Public Health Service in North Carolina, and later Director of the Hyde Park, Massachusetts, Young Men's Christian Association, doing much towards raising the money for its building and construction. Later, he became Director of the Falmouth Institute for Biological Research. In 1936, he became a member of the staff of Franklin Technical Institute as an instructor, first in chemistry, then in mathematics; and for the past ten years was Supervisor of Admissions and Placement.

Mr. Hughes had been actively interested in technical institute education for over fifteen years. He served for a time as Vice President of the National Council of Technical Schools and was the first Chairman of the Technical Institute Division of the American Society for Engineering Education. Through his efforts a very constructive program was laid out for the first meeting of this Division, held in Austin, Texas, in 1948, and for the meeting last summer in Troy, New York. He was the originator and first Chairman of the National Committee of 21, whose purpose was the organization of the various factors in the technical institute field, and the planning of the program for the Technical Institute Division at the annual meetings.

Interdepartmental Cooperation for Better English

By D. E. MACK

Professor of Chemical Engineering, Lehigh University

Some institutions are well ahead of others in interdepartmental cooperation for better English. Where this problem has been actively attacked, a number of methods have been evolved which seem to have had success.

Our program at Lehigh University has not yet advanced to where we can point with pride to our accomplishments. However, we believe that we have managed to surmount the first and worst barrier, which probably confronts most other old-line institutions; that is to make all of the departments aware that they have responsibilities to each of the others. In other words, interdepartmental barriers must be broken down so that one department is aware of what another is trying to do and is willing to help achieve the ultimate goal.

Our first step in attacking this general problem was to appoint a committee, with its membership drawn from several of the technical departments and the department of English. We expected to formulate definite plans quickly and to see improvement in a short time. This was not the case. Each plan presented met with so many practical difficulties that it had to be abandoned, and we were left only with the original problem. The practical difficulties we encountered were such things as teaching schedules, curriculum changes, conflicts with the "humanistic social core," and general inconvenience. Even had any of the plans worked out, the results might not have been worth the trouble they might have caused.

A New Approach

Therefore, we decided to attack the problem from a more philosophical point of view. We asked each member of the committee the question: "What are you *personally* doing to improve the quality of the English used by *your* students?" The answers to this question pointed the way to what we believe is the real solution to the problem. At first, each representative from the technological divisions had to admit that he had been expecting the English Department to do the job, and each had excused himself with the same arguments:

1. That the English Department had taught them enough English, and
2. That he personally did not feel competent to criticize or to teach English as part of his job.

After we had brought these facts into the open we could see how ridiculous such assumptions were. And yet further investigation brought it to light that most of the faculty were operating upon them.

Our first job, then, became clearly defined. We must re-educate the faculty to become personally responsible for assisting the students in developing their ability to express themselves clearly, both in writing and in speech. We felt that the best way to do this was for each member of the committee to develop his own methods, and to infect the other faculty with the idea of developing similar methods. The results have been encouraging. Quite a number of the fac-

ulty have cooperated and have developed their own ways of helping students improve their English. We have also seen a change of student attitude. At first the students fought bitterly for their presumed right to indulge in habits of bad English outside of their English classes. Now, however, they have accepted the standards, and some have even reached the point where they search for the neatly-turned phrase and lucid description, with considerable pleasure.

Methods Used

Some of the methods we use in the Chemical Engineering division, although not especially new, may bear repeating.

1. We use essay-type examinations whenever possible, and students are penalized for a poorly written paper, even though the facts may all be there.

2. Mathematical-type explanations must be presented as ideas rather than as numbers only. We continually ask the students to "talk a little" between numbers. We believe that a mathematical development is as much an English composition as is pure description.

3. We try to compare the treatment of the same technical material as covered by different authors, with the aim of showing that the same things can be said more clearly or less clearly, and that the reader, not the writer, is the ultimate judge. This type of presentation helps to eliminate the idea that some students have, that "anyway to say it" is good enough.

4. All student requests are made in the form of a business letter to the teacher, be they absence excuses, requests for make-up examinations, complaints about paper-grading or what not. These letters are not accepted unless they are up to standard. This gives the student valuable experience in writing business letters, helps clarify his thinking, and also furnishes a valuable record for the teacher.

5. Students are shown adequate means for presenting a set of facts. Proper use of tables, graphs, and drawings is stressed. Good and bad examples from the current literature are presented. In the case of drawings we must augment the work of the Mechanical Drawing Department in much the same way as we augment the work of the English Department.

6. Model Reports have been prepared by the staff, and are available to the students. Lists have also been made of proper abbreviations, acceptable nomenclature, and ways of handling sample calculations.

7. Private conferences to discuss student reports are advised. Many criticisms and suggestions for improvement which cannot be adequately handled in marginal notes can be brought to the student's attention during these conferences, and he can more readily be helped to see how he, himself, can improve his report.

8. Probably the best way we have of emphasizing all of our teaching is by having the students write what we call a "comprehensive" report. At the end of each semester each student is given a set of student reports which cover the semester's work on a particular piece of equipment. He is asked to study these reports and then to write a comprehensive report which will include and correlate all of the information to be found in the set of reports. He must criticize, re-calculate, if necessary, and evaluate the information. This study of the reports of other students makes him aware, as nothing else can, of the importance of good report writing as well as of careful experimental procedure and of accurate calculation. The student sees that many of the reports are quite unintelligible and that some are very clear. To be forced to *use* a report, rather than to inspect it only casually, gives him a new point of view. He realizes that someone has his own reports and is laboring over them just as he is over theirs. Student comment is to the effect that they learn more about the importance of good report writing, and the importance of clarity of presentation, during this period than at any other time. I can recommend this

device highly as a good, many-purposed, teaching tool.

9. Occasionally we pretend that a report is being presented as court evidence, and try to see how badly the meaning of it can be misconstrued. The report-writer is not permitted to clarify any of his writing during his cross-examination, but the report must stand on its own merits. This sort of thing need only be done once or twice to show the importance of unambiguous writing.

Ideas for improving the students' writing ability and clarity of expression are not hard to find once the teacher has accepted the responsibility in the matter. The department of English usually does an excellent job on the fundamentals. However, if we of the technical teaching staff do not keep ourselves aware of their work, and carry on from where they stop by helping the students *use* what they have been taught, we cannot expect to develop good expression. Our work should not be the teaching of a set of facts but rather the guiding of the students' efforts to achieve an objective. The English Department has given him the tools and has shown him how to use them. We of the technical departments must see to it that he becomes a skillful craftsman.

Industrial Engineering—What Is It?

By F. H. THOMAS

Professor and Head, Department of Industrial Engineering, University of Buffalo

The author has no intention of trying to answer the question, for reasons which will be obvious. The purpose of this paper is to bring to the attention of those interested the wide variety of ideas of what Industrial Engineering consists, as indicated by courses offered in curricula approved by the E.C.P.D. under this title.*

Of the schools so approved, it is interesting to note the variations in curriculum title. Of the eighteen approved schools represented in the accompanying tabulation, eleven use Industrial Engineering; three use Administrative Engineering; two use Management Engineering; one uses Business and Engineering Administration; and one shows it in the catalog as an option under Mechanical Engineering, though E.C.P.D. lists this school as Administrative Engineering. One approved curriculum is omitted because of insufficient data.

Course titles are frequently somewhat vague, and for the purpose of this paper, no determined attempt was made to discover the exact course content, but the attempt was made to place apparently similar subjects under one general title, thus any course that appeared to have to do with personnel was placed under this title; statics and dynamics are under mechanics, though materials testing and fluid mechanics are treated as separate subjects; all shopwork is under shopwork, etc. Therefore, the tabulation gives no indication of the amount of work offered in any case. The author feels justified in handling it this way, since he wants only to bring to your attention the general lack of uniformity in curricula.

The first item of interest is to see wherein curricula do agree, and here, as educators would expect, we find that all schools offer the basic courses of Accounting, Chemistry, Drawing, Economics, Electrical Engineering, English Composition, Mathematics, Mechanics, and Physics. Next most common are Industrial Management, and Motion and Time Study, with Shopwork and Strength of Materials following closely. It is necessary to emphasize that the listings are of required work, of subjects listed in catalogs by title; that no optional courses are shown; hence actual agreement among curricula might be somewhat closer if these were known for each case.

Continuing the examination, we find a gradual widening of requirement until we come to a point where only one school requires the particular subject. All of the latter were omitted from this tabulation as having no particular bearing. It is believed that many of these subjects are a matter of convenience, that they are often in curricula because they are a hobby or specialty of a staff member or because of availability, rather than because they are considered essential to the program.

This lack of agreement exists, not only among schools, but among the men practicing the work in industry. This University established its School of Engineering in 1946 and at that time, a questionnaire was sent to some three hundred industrialists in this territory who, conceivably would know the needs of the Industrial Engineer. The results were so amazing that they are almost unbelievable. The re-

* October 1948 report.

cipient was asked to check each subject as "essential," "desirable if time permits," "elective only," and "non-essential." It was interesting to note that with the one exception of Algebra or Trigonometry, which are normally high school entrance requirements, every one of our so-called basic courses were indicated by one or more of these men as being non-essential, and in some cases, a majority of the men listed them below the essential category. As examples of Industrial replies the following are the percent "essential" tabulations for some of our basic courses;

SCHOOLS TEACHING UNDER THE FOLLOWING CURRICULA

Industrial Engineering—1 to 12
Administrative Engineering—14 to 16
Management Engineering—18, 19
Business and Eng'g Admin.—21
Option in other curricula—23

Subjects	Subjects as Required of All Students																					Totals
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Accounting	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Chemistry	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Civil Engineering:																								
Structures				x										x										2
Surveying					x		x																	2
Drawing	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Economics	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Electrical Engineering	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Electronics		x					x		x										x		x			5
Engineering Economy		x	x	x	x		x	x						x										7
English:																								
Composition	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Speech	x			x	x	x	x	x			x			x		x							x	10
Technical writing							x		x		x			x	x	x								6
Finance						x			x	x				x	x						x			6
Fluid Mechanics		x			x		x	x				x		x							x		x	8
Heating and Air Conditioning						x	x																	2
Heat Power	x					x	x	x		x		x		x	x	x					x		x	11
Hydraulics						x									x									2
Ind'l Org'n—Management	x	x		x	x	x	x	x	x	x	x	x		x	x	x		x	x				x	17
Labor Relations	x	x		x								x			x			x	x		x			8
Law	x	x				x	x	x	x	x	x				x			x	x		x			12
Machine Design	x	x	x	x	x		x		x	x		x		x	x						x			12
Manufacturing Processes			x	x		x	x		x		x	x		x	x	x			x					11
Marketing															x			x	x		x		x	5
Materials:																								
Engineering	x	x		x	x	x	x	x			x				x				x		x		x	12
Mechanics of							x			x					x	x								4
Strength of	x	x	x	x	x			x	x		x	x		x				x	x				x	13
Mathematics	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
M. E. Laboratory					x	x	x	x	x		x	x				x								8
Mechanics	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Mechanism	x		x	x		x	x																x	6
Metallurgy				x			x	x		x		x			x						x			7
Motion and Time Study	x	x	x	x	x	x	x	x			x	x		x	x	x		x	x				x	16
Operation Analysis				x				x	x			x												4
Ordnance Gage Laboratory												x												2
Personnel	x	x		x		x		x	x	x				x				x			x			10
Physics	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x		x	19
Plant Layout	x	x	x	x	x							x		x										7
Production Control		x						x	x									x	x					5
Producting Engineering		x										x									x		x	4
Production Planning	x			x		x	x	x							x			x	x					8
Psychology		x						x		x	x			x	x			x						8
Quality Control	x	x				x	x							x										5
Safety Engineering		x	x		x																			3
Shopwork	x	x	x		x		x	x	x	x	x	x		x	x	x					x		x	15
Statistics				x		x				x	x	x		x				x	x		x		x	10
Thermodynamics		x	x		x	x				x	x	x		x	x	x							x	12
Tools—Design or Engineering	x	x			x		x	x						x										6

Note: No. 12 not yet accredited by ECPD.

Chemistry 32%, Drawing 80%, Descriptive Geometry 38%, Economics 54%, English (general) 74%, Electrical Engineering 33%, Analytical Geometry 48%, Calculus 31%, Statics and Dynamics 39%, Metallurgy 19%, Physics 61%. The only logical conclusion one can reach is that the questionnaire was answered, in most cases, in terms of subject matter as being put to use by the individual in his work. Then too, when one examined the reactions to the more or less strictly Industrial Engineering subjects, he found a great preponderance of "essential" indications. This seems to confirm the fact that the answers were primarily in terms of individual use or contact.

How then are we to build curricula in Industrial Engineering? How are we to meet the need of industry if neither the industrialist nor educator can agree on what is essential and what is non-essential? It seems evident that it is time we in this field of instruction sit down and take stock; that we decide, not what we are trying to do, but what we intend to do; that we make a very critical study of the field in an attempt to determine the basic needs and adjust our curricula in accordance. If our local study is of any national import, perhaps we might pose the question of whether or not it is up to our schools to tell industry what it really needs and what it should expect of our graduates.

As indicated above, the material presented here was at hand when our curriculum was prepared in 1946, and as a result, it was determined that, first of all, we must train our students in engineering, then give them a reasonable amount of specialized work in the field of Industrial Engineering. Our first graduates went out in June of 1948 and were followed by a small group in February and 17 in June 1949. It is going to be extremely interesting to us to follow these graduates and their progression in the field. Meanwhile, we shall continue the attempt to find the answer to "Industrial Engineering—What Is It?" Perhaps this is a field of investigation suited to a committee of the A.S.E.E. Perhaps it is more of a situation to be solved in terms of the work in which graduates of individual schools find themselves. But whatever it is, it is believed that we cannot continue to go merrily along in our individual ways much longer before a critical survey is made.

The Business of Higher Education[1]

By WILLIAM B. PLANK

Professor of Mining Engineering and Head of Department of Mining and Metallurgical Engineering, Lafayette College

In order properly to consider the "Financial Crisis of the Colleges" we should examine some of the aspects of the business of higher education. We are a nation of "big business" in the commercial sense and, as one of the following speakers will point, we also do the *biggest business* in *higher education of* all the nations of the world.

There must be a balance sheet for this business of higher education as there is for all other businesses, but when the characteristics of these balance sheets are examined we see that they are astonishingly dissimilar. In a manufacturing business, for example, the cost of making an article, as well as supplying a profit to the stockholders, must be included in the price the customer pays for that article. In the business of higher education, however, the customer—the student—never pays the full cost of the education he receives. Indeed, toward each dollar of cost for his education the college student pays only about sixty cents. The remainder is made up from the income of gifts of endowment funds and from gifts toward the direct operating expenses of the college.

Because of the inability of colleges to adjust their finances quickly to changing costs and markets we rarely find their finances in good condition. They, of course, are not operated for profit, nor should they be, but rather they are constantly carrying on campaigns for money to pay better salaries to their teachers, to build new dormitories, to construct new and larger classrooms and laboratories, and to make up the deficits in operation.

Unbalanced Budgets

Their budgets are always out-of-balance, if they are properly drawn. But today and in the years ahead, the financial prospects for the colleges appear alarming to many who are concerned with the situation. This is because of the unprecedented size of the student bodies, the higher cost of all the services rendered to them, and at the same time the drying up of large private fortunes from which the endowment funds have come in the past. It seems inevitable that college treasuries will experience larger and larger deficits unless prompt financial assistance is forthcoming soon.

I might add that these financial difficulties confront both the privately endowed institutions as well as the state universities and for the same reasons. But in the case of the state universities the deficits are made up from the public treasuries through taxation. The situation is what we have termed "The Financial Crisis of the Colleges."

Since some of us need numbers to aid our thinking, especially about business, in my part of this program I shall present some information to show the changes that are taking place in the size of the job the Colleges are being called upon to do, as compared with the pre-war situation, and the situation as it may be in the years immediately ahead. Other speakers, following me, will discuss the possible ways of meeting the ex-

[1] An address at A.A.U.P. Public Forum at Lafayette College on "The Problems of American Higher Education," March 3, 1949.

penses and covering the deficits of the colleges.

Volume of Enrollment

First let us look at the volume of business the colleges are doing and examine the enrollment figures.

The Office of Education, in its last directory, shows that there are 1688 institutions of higher learning in the United States. Of these, 356 are State controlled, 192 are municipal, 450 are private, 478 are under Protestant Church control, and 212 are controlled by the Roman Catholic Church. Fifteen hundred eighty-four are for whites and 104 are for negroes. By kinds of institutions, there are 782 Colleges and Universities, 265 Professional and Technical Schools, 212 Teachers Colleges, and 429 Junior Colleges. Two hundred six are for men, 266 for women and 1216 are co-educational.

In these 1688 institutions, 2,410,000 students are enrolled in this present academic year as compared with 1,490,000 in 1940–41. This represents an increase of 62% in eight years. During this same period the number of engineering students, included in the above total, has increased from 113,500 to 241,500, or 113%—nearly twice as fast. Today the engineers comprise 10% of the total college group, whereas in 1940–41 they numbered only 7.6% of the total.[2]

As an indication of the size of the job the colleges will be doing in the future, a government bureau has estimated that we can expect 3 million students to be enrolled in the institutions of higher learning of the country by 1960, or 12 years hence.

For the engineering groups, however, the situation is a little different. The all-time peak in enrollment in engineering was reached last year when there were 245,000 students in the 150 engineering schools of the country. The turn of the tide in engineering students is undoubtedly caused by the change in the veteran situation. This year the veteran engineers made up 64.1% of the total, with the highest percentage in the senior class where they number 82.5% of the class. Among the freshman engineers, however, there are only 36.6% veterans, and of course the number will rapidly decrease from now on.

Another factor that leads to the prediction of engineering enrollments at a lower level than at present, is the disparity in the normal sizes of the classes. The freshman and graduating classes this year are about the same size, whereas the freshmen class normally should be twice the size of the graduating class. Just where the engineering enrollment will level off to is impossible to predict but I hazard the guess that in about 3 years hence it will be about 200,000, or about 20% lower than at present.

The proper handling of this question of determining the sizes of student bodies requires the utmost wisdom and ability on the part of all who are concerned with college administration. Not only the financial welfare of the colleges but their reputation and very life depend on how wisely the solution is performed.

Salary Situation

Now let us examine the situation with regard to teachers' salaries and see how it affects the finances of the colleges.

Unfortunately, we find that the colleges have not kept up with the rising cost of living in the salaries they pay their teachers. In a study recently made by a committee of the American Association of University Professors on the "Economic Status of the Teaching Profession," [3] it is pointed out that the cost of living index of the Bureau of Labor Statistics rose from 133.3 in July 1946 (1935–39 = 100) to 177.7 on June 15, 1948, making a rise of 28.8%.

It is readily understood why the colleges are having difficulty in recruiting additional teaching staff, let alone holding their regular staff, when we consider that during this same period of two years the minimum salary increases paid to

[2] *Journal of Engineering Education*, February, 1949.

[3] A.A.U.P. *Bulletin*, Vol. 34, No. 4, Winter 1948.

college teachers in 16 representative institutions were: for Professors, 9.4%, for Associate Professors, 8.5%, Assistant Professors, 9.2%, and for Instructors, 12.9%.

For further testimony on this point it is recommended that you read the articles in *Colliers' Magazine* for February 26 and March 5, 1949, entitled, "College Teaching Doesn't Pay" and "Why I Quit College Teaching."

Another factor that has a direct relation to the financial condition of the colleges is the ratio of students to faculty. On this point the above mentioned committee finds that the over-all proportion of students to full-time faculty in the 42 institutions covered is 20.5. The committee states that these figures compare favorably with the objectives proposed by the President's Commission on Higher Education. The Commission recommends, "as a general pattern," a national average ratio of 20 students per faculty member for the first two years of college, 13 for the last two years, and 10 students at graduate and professional school levels."

Although the average ratios are not out of line with those recommended, the committee states that there is no doubt that the great increase in enrollment of students in the past three years has tended to push the ratios appreciably above pre-war levels. "In one extreme case the enrollment is nearly twice the pre-war figure, while the faculty is only 10% larger. The result is the highest ratio of students to faculty of any of the institutions studied, a ratio nearly 100% higher than the recommendations cited above." There can be no doubt of the deterioration that instructional standards have suffered at that institution.

Expenditure Per Student

The most significant tests of the instructional adequacy of the colleges are the figures on the amounts spent per student for instruction. The figures given in the A.A.U.P. Committee's report include, in addition to the salaries of full-time faculty members, the salaries of part-time instructors and assistants, as well as pension and insurance fund contributions. The committee states that these figures are more significant than the faculty-student ratios and "are as accurate a measure of educational standards as is available in terms of numerical symbols or money values."

The average expenditure per student for instructional salaries for all 42 institutions studied was $379 in 1947–48 and it is estimated that it will be $413 in 1948–49, an increase of 9% in one year.

To get a contrast with pre-war figures, comparable data from five New England colleges showed that the dollar expenditure per student was 6.2% lower in 1947–48 than that planned for 1948–49. In order to make the comparison accurate, however, we must allow for the decline in the purchasing power of the dollar since 1940–41, and when this is done we see that the *real instructional expenditure* per student in 1948–49, in these five institutions, is only about 60% of that in 1940–41. Thus it is seen that the customer of higher education is getting much less for his money today than he was before the war.

Finally, and in conclusion, this analysis of the business of higher education seems to leave no doubt that the colleges are facing a financial crisis.

The evidence appears overwhelming that, if the colleges are to maintain their pre-war standards of instruction in all of its aspects, and at the same time the students continue to pay for only about 60% of the total cost of their education, then the argument that college budgets can be balanced merely by increasing the enrollments is fallacious. It appears to me that by so doing the colleges are only compounding their deficits.

If our colleges continue to dilute the services they render in higher education then their performance will get so thin and of such low quality that the public will not buy their product. This is one of the serious aspects of this problem that applies to the small privately endowed college that has no recourse to public subsidies.

Graduate and Research Work in Universities and the Use of College Men in Industry and Government*

By NICHOLAS J. HOFF

Chairman of the Symposium, *Professor of Aeronautical Engineering*

and

VITO L. SALERNO

Recorder of the Symposium, *Associate Professor of Applied Mechanics, Polytechnic Institute of Brooklyn*

Purpose of the Conference—N. J. Hoff, Professor of Aeronautical Engineering, Polytechnic Institute of Brooklyn

As a consequence of the contribution of technological advances to the winning of the last war, the value of the sciences and of research work of a theoretical nature is appreciated today by the general public as well as by government and military agencies much more than ever before in the history of this country. The question arises, therefore, whether the established practices of graduate training are still satisfactory in this post-war era. Some persons believe that the accumulation of basic knowledge and the spread of applications render the traditional four year undergraduate study period insufficient for engineering education. Possibly five or six years' work should be required for the bachelor's degree. Such a change in the requirements would tend to bring the training of engineers closer to that of other professional men, for instance doctors and lawyers.

The number of graduate students has increased considerably and more of these students are interested in research work than before the war. More men with experience in research are employed in industry and government. Is it still desirable, as it may have been years ago, to give practical application courses to candidates for the master's degree, and require a thorough study of the fundamentals only of the candidates for doctorate? As a matter of fact some leaders in the industry want the colleges to teach almost exclusively fundamentals in physics and mathematics even on the undergraduate level. They feel that with the rapid advances in aeronautical engineering any factual knowledge of accepted practices and government regulations becomes entirely worthless in a few years. On the other hand, many educators still want to provide the students with a considerable amount of factual information so as to make them immediately useful when they enter ind[illegible] after having received a bachelor's degree.

While working for advanced degrees graduate students often rely partly or fully upon income from paid research work performed at the colleges to cover their tuition fees and living expenses. By far the greatest part of the research

* Summary of a Symposium Sponsored by the Aeronautical Division at the Annual Meeting of the A.S.E.E., Troy, New York, on June 24, 1949.

funds is provided today by government agencies. The question arises, therefore, whether the restrictions imposed upon research sponsored by government or industry are likely to lead to a loss of our academic ideals? Is it desirable that the colleges become less dependent upon contractual work or should the contracts be modified in spirit in order to make them more suitable for promoting true academic work?

What is the value of graduate work to the engineering colleges, the students, industry, and government? Is the education of the student completed at the master's or doctor's level? Should post-doctoral fellowships be encouraged in our colleges or should the education of the research man preferably be continued in non-profit research institutions or in jobs in industry or government?

All these problems are of considerable importance to the development of the colleges, industry, and society in general in this country, and even to the security of the United States. The colleges and the engineering profession have an obligation to solve these problems and the American Society for Engineering Education is best suited to provide a forum for their discussion. This is the reason the present conference was organized.

The Viewpoint of Government Agencies —R. M. Robertson, Director, Physical Sciences Division, Office of Naval Research, U. S. Navy.

The Navy Department has many interests in the graduate schools of science and engineering. First, the Navy depends on these schools for technically trained civilians to man its laboratories and development facilities, and to create a reservoir of highly trained personnel to be available in an emergency. Second, the Navy selects promising young Naval Officers and sends them to graduate schools for additional specialized training. Third, the Navy depends heavily on these schools for basic research in technical fields underlying its entire development program.

The Office of Naval Research is an outgrowth of the Office of Research and Inventions, which was organized in 1945 as the central Navy group responsible for research. Its purpose is to carry out and sponsor broad research programs in fields of interest to the Navy and to coordinate all Naval research. The sponsored program is the responsibility of the Research Group under the Assistant Chief for Research. The program covers all the major fields of science and has been largely built on the basis of proposals received from scientists. Practically the entire program is free from security restriction, and scientists are encouraged to publish their work as soon as it is completed.

The Research Group of the Office of Naval Research is not engaged in a program of federal support for education. Its job is to sponsor research in fields supporting the Navy's long-range development requirements. The fact that about 80% of its program is in universities and colleges reflects a belief that basic research flourishes best in the academic atmosphere. Training of graduate students is regarded as an important by-product of the sponsored research effort.

The magnitude of the ONR program is such that it cannot fail to have a great impact on graduate training. The ONR has no fellowship program, but hundreds of graduate students are being supported by funds from ONR research contracts. Since the ONR has no authority or desire to shape the educational pattern of the country, it is squarely up to those responsible for graduate training to see to it that the impact of government supported research does not adversely affect our graduate schools. Research is a normal and necessary function of graduate schools. In ONR, this is recognized by insisting that Navy funds be used to augment research, rather than to take over its entire cost.

The writer believes that there are a number of dangers inherent in the acceptance of large research grants. The first lies in the possible commercializa-

tion of university research for profit to the institution. Carried to its logical conclusion, the present trend toward setting up institutes to "sell" the research potential of a school can result in serious loss of academic freedom. For example, pressure may be brought to bear on individual scientists to work on subjects popular with the sponsor.

A second problem allied to the first is that control of educational and scientific policy in our schools may pass from the hands of scientists and educators into those interested in exploiting the scientists for financial reasons.

A third danger arises when a decision is made to embark on a research program requiring security classification. The writer personally believes that security restrictions are incompatible with the free pursuit of knowledge in the academic tradition. The ONR attempts to place only unclassified research in universities. If a discovery of military importance is made, it is the usual procedure to transfer the work to a government or commercial laboratory for development under proper security control.

As a pioneer in providing broad support to scientific research, the Office of Naval Research has attempted to study and understand the problems raised within universities which accept its support. It has carefully refrained from interfering in the internal problems of the universities, but has succeeeded in many cases in adjusting its policies to provide a mutually satisfactory relationship.

The Viewpoint of Non-Profit Research Institutes—C. C. Furnas, Director, Cornell Aeronautical Laboratory

In applied research in the aeronautical sciences there is a particularly large premium on a sound scientific background, constructive thinking, and versatility. The man with a bachelor's degree, whether in aeronautical engineering or something else, is not sufficiently well grounded or experienced to make many contributions. He is essentially one of the hewers of wood and bearers of water, of which, of course a number is needed. If he is alert, Cornell Aeronautical Laboratory can help him to acquire continuing self-education quite rapidly. He can also undertake formal graduate work outside working hours. Many do. It helps him and the Laboratory, too.

Expressed another way, we find that the undergraduate degree alone is inadequate for constructive research work. Men with at least some graduate work are preferred but the B.S. man, if capable and willing, can build up fairly rapidly on what he has. Originality is the foremost quality of the good research man and college education does not seem to produce men with new ideas. There is no single preference as to the type of undergraduate training, if the man comes with that alone. A good aeronautical engineer from a good school does as well as the others but he has no edge. The average undergraduate aeronautical engineer usually is short on fundamental knowledge and has not developed a facility for exploring new fields. Apparently emphasis on specialized knowledge has started too soon. Mechanical and civil engineers seem to average better. Physicists and applied mathematicians of the modern variety also appear to have good backgrounds.

For the purposes of aeronautical research, aeronautical engineering instruction should be primarily in the graduate field. A few aeronautical courses in undergraduate years to orient thinking and interest are useful but to try to make an aeronautical engineer (useful in research) in four years does not seem possible.

Men with a B.S. only in aeronautical engineering will always be useful in the normal production engineering of aircraft plants and probably in aireraft operations, but with that degree alone, their technical ceiling is very definitely limited As in all lines, administrative talents may become apparent in later years, and one having it can climb to

higher levels. Administrative rise, however, is based on many other things in addition to technical ability.

In the opinion of the writer definite task-type research is a powerful adjunct and probably should be made a necessary part of graduate training for aeronautical research. Since nearly all aeronautical research is at present supported directly or indirectly by government, it seems inevitable that graduate aeronautical training is going to be closely linked with government-supported research. A certain amount of this can be handled by academic departments themselves, but it can be overdone to the detriment of the fundamental educational activities. Research foundations, where the prime objective is research and not education, can be very useful here, particularly if they are crosslinked in some way with universities. Government laboratories, such as the NACA, can also be an aid if continuing cross fertilization with educational institutions is pursued. The research laboratories of the aircraft companies (they are usually development rather than research laboratories) can serve in rounding out the educational background also though, as a whole, they have done very little constructively along this line.

In order to make the training and the research in the aeronautical sciences more effective, there should be very close, working collaboration among graduate schools of universities, government laboratories, research foundations and industrial laboratories. Though considerable work has been done in such collaboration, the progress has really been rather desultory. The aircraft industry, particularly, could be most helpful in requiring and helping to support graduate and post graduate training through well-organized, carefully planned programs.

Viewpoint of the Aeronautical Industries —P. R. Bassett, President, Sperry Gyroscope Company

The basic problem confronting engineering educators is how to introduce the new generation of engineers to the ever changing methods of technology. The increasing difficulties of preparing an engineering student for work in aviation are illustrated in Fig. 1. In the graph the amount of technical knowledge is plotted against time. The region "A" represents the period when technical knowledge was passed on from father to son in the guilds of the Middle Ages. It

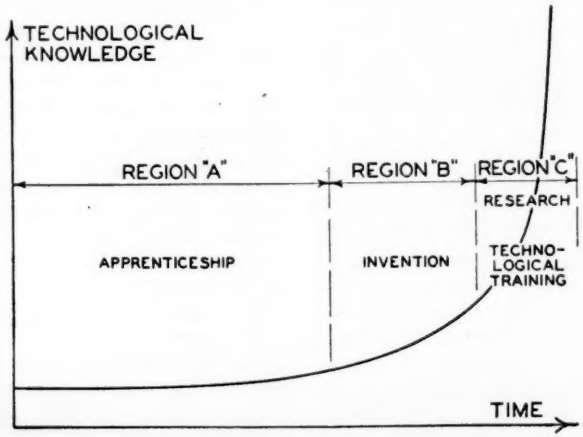

FIG. 1.

also includes the time when the foundations of science and technology were laid during and after the Renaissance and in the earlier parts of the last century. But technology was progressing slowly and the artisan-engineer after having spent a youthful apprenticeship in attaining mastery of his profession could produce a lifetime of useful work without altering his ideas on engineering or "know how" to any appreciable extent. The region marked "B" can perhaps be called the period of purposeful invention. Such men as Edison, the Wright brothers, Glenn Curtiss, etc., made their contributions to engineering during this period. They had little formal training but many original ideas. As the curve of technical knowledge was rising more rapidly a greater percentage of the lifetime of the average engineer had to be devoted to the acquiring of knowledge and he was faced with the new problems of keeping up to date or else losing his usefulness.

Part "C" of the graph represents the present state in engineering. Technology advances so rapidly that the knowledge of the average engineer having the usual college education very soon becomes obsolete. It is imperative, therefore, that schools give the broadest possible training in fundamental concepts. Even graduate work should be kept fundamental. Graduate work done in too limited fields of specialization tends to make the engineer lose his usefulness under the impact of rapid development.

During the first ten years of the Sperry Gyroscope Company's activities less than 40 per cent of the technical personnel had bachelor's degrees. The rest had no degree whatsoever. Men with master's degrees were first employed by the company about fifteen years ago in order to carry out research. At the present time, of the 600 technical employees 380 have bachelor's degrees, 110 master's degrees, 10 doctor's and the remaining 100 no degrees. This year about half of the new employees will have bachelor's degrees and the other half master's degrees. The broad statement can be made, therefore, that during the lifetime of the Sperry Gyroscope Company the educational requirement for employment has been increased by one academic degree.

In conclusion it should be emphasized that present day education should first of all provide a broad background to enable the engineer to advance his knowledge during his years of employment with the present high rate of technical development.

Viewpoint from a University—Arnold M. Kuethe, Professor of Aerodynamics, University of Michigan *

The training of a research worker requires the development of an intellectual curiosity and a background of sound concepts which is in general beyond the scope of the four year course in engineering. While it is possible for the superior four year graduate to acquire the necessary skills through individual study, the great majority require further formal training in engineering science and mathematics to be effective in research as well as in many phases of development work.

A healthy industrial development involves a balanced program of basic and applied research with as small a lag as possible between basic discoveries and their exploitation. Graduate schools in engineering must, therefore, give the development engineer an appreciation for and an ability to understand the basic sciences, and they must teach an appreciation of applied aspects to those students who will gravitate into basic research.

This objective cannot be achieved by differentiating widely between the curricula for these two groups. A wide choice of courses should be provided to fit the individual's interests and abilities, but the vast majority of them should be directed toward the study of fundamentals. They should lead to an understanding not only of current practice in engineering, but also of concepts which might

* Excerpts from a longer paper prepared by Dr. Kuethe for the Symposium.

bring about changes in current practice some years hence.

In undergraduate training the objective is to provide as much fundamental training as possible and still be consistent with the principle that the graduate must have enough of an introduction to current practice to make him an effective engineer after a relatively short "on the job" training. This objective might be stated in various ways; it requires interpretation concerning the extent to which fundamental or applied courses should dominate the curriculum.

In gradnate work on the other hand, there is less differentiation between fundamental and applied courses because by this time the student has the background and the maturity to carry through many problems from basic assumptions to a conclusion which can be applied to practice.

All engineering courses should have a practical objective; that practical objective, however, involves as much a clear understanding of the phenomena treated as it does a knowledge of methods for calculating useful results. Only through an understanding of the phenomena is the engineer able to appreciate the range of variables over which a given method of calculation is valid.

The thesis, whether it be on the bachelor's, master's, or doctor's level, represents the ultimate in the tutorial system and, as such, it is highly desirable. However, if it is to be a rigid requirement for the bachelor's or even for the master's degree, a large lightly-loaded teaching staff must be available to guide the student. The educational value of a well-executed piece of research approaches the ultimate for any comparable expenditure of time; on the other hand there is something like an exponential decay of the educational value with the degree of compromise with thoroughness.

The revolution in university research during and since the war, brought about largely by the availability of extensive government contracts, has brought with it many problems. Should classified contracts be taken? Is the design and production of "hardware" a legitimate activity? Should the faculty receive extra compensation from contract funds? Should students be paid to work on their dissertations; and if so, how much? How much student participation in contract work is feasible or desirable? Should universities undertake the building and operation of installations so large that they could not possibly utilize them in the absence of extensive outside support? Is it justifiable for a university to operate an installation devoted largely to routine test work? Does the contract system fit the individual research worker into a groove, thus inhibiting him from striking out in little known or untried directions? Is it justifiable to permit the teaching staff to spend any considerable amount of their time on simply the administration of research projects? These and other questions have been recognized and have been answered in many ways by many institutions.

Only a few of these questions will be discussed here specifically. Most of them cannot be answered categorically; President Killian* described M.I.T.'s tussles with some of them and indicated some workable solutions. Other institutions have achieved a relatively high degree of participation in the national research program with a different set of answers to the same questions.

Any university which offers graduate work must have a staff which engages in research; otherwise the inescapable result will be a gradual deterioration of the graduate courses. The guiding principle must be that the research activity of any member of the teaching staff shall be of such a nature that it will improve his ability as a teacher and will reflect credit on the university. As an example, if a university enters into a large contract, the work must be very carefully organized so that members of the teach-

* J. R. Killian, Jr.: "Research Policies at M.I.T." *Journal of Engineering Education*, Vol. 38, No. 3, November, 1947.

ing staff are not spending their time simply administering the project. Participation of this kind brings small returns in the way of making a man a better teacher, scientist, or engineer. It seems to the writer that the ideal situation is one in which each faculty member spends his research time working with a small number of graduate students in the area in which he is most competent. Whether he does this as a sub-project under a large contract or as a separate project is unimportant; it is important however that he not be high-pressured into undertaking the work and that he be permitted to "follow where the work leads" instead of being required to achieve in detail a set objective at a given date. It is also important from an educational standpoint that students be permitted to discuss their work freely; from this standpoint classification of contracts in universities is undesirable.

Large research contracts, involving annual expenditures of a million dollars or more, were unheard of in university circles before the war. One of the greatest difficulties inherent in the large contract is that of building up an adequate staff during the time interval covered by the contract, especially considering the dangers of non-renewal, cancellation, or curtailment. The personnel and technical qualification of the key personnel should probably be higher than for a comparable position in industry since there is the additional requirement that the work must aid, or, at the very least, not hinder the educational function of the university. The kind of organization chart which will accomplish this end depends on the nature of the work and on the personnel available. For these large projects there is much to be said for an organization which is complete within itself and is tied in administratively with the university only at the level of the governing body; it would of course be tied in technically with the teaching staff and students through research.

The nature of contract work must, of course, represent as closely as possible the main interests of the faculty. Just as the interests of an effective teaching staff in an engineering college must represent a balance between basic and applied science, so should the research program represent a similar balance. Since thesis work more often leans toward basic research, the program should perhaps be slanted in that direction.

A word should be said here about the attitude of government organizations toward university research. It appears that such bodies as the N.A.C.A., the O.N.R., the O.A.R., the Signal Corps and others have an awareness of the atmosphere under which basic research flourishes and of the problems peculiar to university research. Credit belongs to the N.A.C.A. for making a great step forward in the early 1940's when they began writing one page contracts specifying only that research in a given area be undertaken.

Discussion

The presentation of the prepared statements was followed by an extensive discussion. Because of the limitations of space only a few highlights of the discussion can be recorded here.

Professor Sanford (Iowa State College) felt that in order to develop engineers with original ideas inspired teachers were required. He thought that an interchange of inspired men from industry and academic institutes would improve the situation. Mr. Miller (Rensselaer Polytechnic Institute) disagreed with Dr. Furnas in regard to a basic lack of "idea men." He thought that the formal requirements of engineering education often discouraged the development of ideas. The sharp rise of Mr. Bassett's curve in region "C," however, indicated that many idea men were at work.

Mr. Bassett (Sperry Gyroscope Company) found new ideas to be inversely proportional to academic degrees. Dr. Barlow (Texas A. & M.) pointed out that engineers were getting into a difficult

position as Mr. Bassett's curve approached infinity. He agreed with the statements of several speakers regarding the dangers of government sponsored research. Texas A. & M. received $500,000 a year without strings attached which was quite a help in developing "idea men" through self-inspired research. Dr. Staunce (Naval Ordinance Laboratory) observed that college trained men usually did not have the ability to visualize designs and to understand the problems of industry. He was in favor of an arrangement such as the one tried out at Rensselaer Polytechnic Institute permitting men to drift in and out of industry during their college study period.

Mr. Bassett (Sperry Gyroscope Company) found this part-time study and part-time work idea unsuccessful. After trying it out the Sperry Gyroscope Company replaced it by the following alternative opportunities for its employees: (1) The engineer may take night courses in an academic institute. The company pays one-half the tuition fees. (2) An engineer may work half-time and study the other half-time. The company pays one-half the salary and one-half the tuition. (3) An engineer may take a year's leave of absence. The company pays the tuition fees and $1500.00 for subsistence.

At present 150 employees of the company are making use of one of the three alternatives.

Professor Hemke (Rensselaer Polytechnic Institute) was sorry to hear from Dr. Furnas that the average graduate of an aeronautical engineering curriculum was of little use in research. He knew of at least one achievement of the aeronautic curriculum. It gave an impetus for a new development in the older branches of engineering and in the sciences which had been resting on their laurels and slowly decaying in our educational institutions. Professor Barling (University of Buffalo) felt that a generation ago little formal education was necessary to put ideas into a workable form. The situation has changed considerably since that time because of the increasing complexity of technology.

Departmental Organization[1]

By S. H. GRAF

Professor of Mechanical Engineering and Director of the Engineering Experiment Station, Oregon State College

In the good old days, the life of a college professor, and even a department head, was simple and full of dignity. Many of us at this meeting can well remember that when we graduated and got our sheepskins the college was through with us and glad of it. We were kissed good-by with a tremulous and dramatic "Godspeed" and sent out into the cruel world to shift as best we could on our own initiative. Those happy days of the good old ivory tower and ivy clad halls I am afraid are forever past. Gradually students have been led by one circumstance or another to expect more and more in the way of guidance and advice while in school and help in placement after graduation. Not only this, but after graduation they also to a considerable extent look to their department as an employment agency in case they wish to shift jobs.

The school pattern from the organizational standpoint because of greatly increased enrollments and correspondingly larger staffs has also become very complex and calls for an organization diagram similar to those used in industry. Our engineering schools in the Pacific Northwest, although four or five times as large as 20 or 30 years ago, still are small as compared to those of the large institutions such as the University of California, the University of Minnesota, and many others. Due to human limitations, the point has been reached in such schools where it almost appears advisable that there should be two or perhaps three completely separate and independent engineering schools on the same campus. Beyond a certain size, overhead costs of duplication become relatively insignificant, and this suggestion of engineering school A, engineering school B, and perhaps even C, has been regarded as having definite merit in order to recapture some of the educational advantages of the small college which very definitely have been lost in these large institutions.

Departmental Organization

As schools of engineering have grown in size so of course have departments and the matter of a better and more definitely integrated departmental organization has become significant. The department is the "firing line" where the educational, advisory, and placement problems of the student are met. In regard to placement, some of the larger schools have set up personnel offices which relieve the department heads of much of the detail of scheduling interviews and handling placement matters; however, it is impossible for a personnel or placement officer to know the personality characteristics and abilities of the individual student intimately enough to do much more than to handle the paper work. If this service is to be effective, in my opinion, it is still the job of the department head with such help as may be available from his staff.

At some schools a system of rotation by elected or appointed departmental chairman has been substituted for the traditional position of department head.

[1] Presented at the Pacific Northwest Section of ASEE, Bozeman, Montana, June 17, 1949.

This has some merit but also several serious and fairly obvious disadvantages particularly in the matter of securing continuity of policy and vision for departmental development.

Aside from the direct services to students already enumerated, a department must concern itself with the following problems and activities:

(a) The selection and training of an able and energetic staff.
(b) The determination of proper and acceptable curricula for the options offered.
(c) The organization of properly graded and integrated major courses as well as service courses.
(d) The development of the necessary physical facilities including buildings and equipment.
(e) The setting up of administrative procedures and housekeeping standards.

Each of these functions will now be discussed briefly from the background of my own experience as Head of the Department of Mechanical Engineering at Oregon State College. In our engineering school there is a common freshman year for the students in Civil, Electrical, Industrial, and Mechanical Engineering, and consequently we are not directly concerned with the problems of the entering freshmen which are handled by the Department of General Engineering. However, even if we were to handle our own freshmen, about the only difference would be that the department head or more likely other designated staff members would take a more active part in the initial registration of the student. It has been our policy to organize the Department into divisions comprising the following: Aeronautical, Heat Engineering (steam power), Internal Combustion Engines, Machine Design, and Mechanics and Materials, with the appropriate staff member designated as division head. Other staff members have been assigned each to a definite division where the major part of the activities of each individual are centered. This practice has value in centralizing responsibility and interest on the part of staff members.

It has been my experience that no matter how fine a school a new staff member comes from at least a term or two will be required for him to become familiar with the courses and facilities with which he is expected to work. Division heads have found it necessary to spend considerable time with new staff members in order to insure their proper training and orientation. Or, in other words, it is definitely necessary to "tutor the tutors to toot" if they are to fit in and become effective.

Curricular Considerations

Next as to curricula and options. In most schools the responsibility for curricular content rests with the department head and of course here such factors as practice of recognized schools, ECPD accreditation, and even to some extent, territorial conditions will govern. There would seem to be little use in setting up an option without at least a recognized potential demand for it.

Under course organization I wish to discuss only two points. The first is that there is need for a closer integration of course offerings so that students will think of the more elementary courses as tool courses to be used later in their more advanced work and not fall into the habit of regarding any subject as closed and pigeonholed forever. The other point is in regard to the attitude of students toward so-called "service" courses. For any engineering curriculum four years is all too short a time and there is no room for any course lacking a very definite need and purpose. We deplore the distinction between so-called major and service courses. Actually there is no distinction except that our service courses are taught by other departments for us or by our own department for others. Because of their equal importance these service courses demand and deserve the same quality of instruction as any others.

This point does not need to be elaborated further as I am sure all present can think of instances where the least able instructors have been assigned to service courses with vehement dissatisfaction on the part of students.

Physical Facilities

The problem of physical facilities, particularly equipment, is always before us. It is strange that administrators will spend hundreds of thousands and even millions of dollars for buildings apparently with no concern as to whether or not these beautiful monuments have anything in them. It should be realized that contrary to the common impression good equipment is the cheapest thing we buy. The salary budget for a department such as mine amounts to a yearly expenditure of over $90,000 and our entire equipment inventory (accumulated over nearly 50 years) totals only about a quarter of a million or less than three times the yearly salary requirement. There is certainly a vital relation between adequate equipment facilities and the effectiveness of instruction. There is little sense in employing a high-grade, well-trained staff member and denying him the equipment that he needs for the proper teaching of his courses, and yet how often this is just what happens.

A department head has innumerable jobs concerned with the selection and ordering of equipment, the anticipation of needs for supplies, preparation of statistics and reports, and many other tasks of which other staff members in general are quite unaware. Staff members, particularly division heads, must be encouraged to exercise vision, to anticipate needs, and to do the preliminary work necessary in the matter of making lists, securing quotations, and preparing all detail necessary in advance of making their requests for needed items. Much time can be saved if these matters as well as submission of grade cards and all other routine affairs are standardized and covered by definite instructions.

The assignment of teaching loads is also a problem that requires considerable thought and effort. In the engineering school at Oregon State all courses are evaluated in terms of "load hours" and instructor loads are adjusted on the basis of 15 load hours as a full load. In each department of course it is necessary to make allowance for extra curricular duties carried on by certain staff members by reducing their teaching loads proportionately. In our department the function of assigning loads has been delegated to a designated staff member but subject to approval or revision by the department head. This staff member is also the chairman of the engineering school schedule committee which makes a very convenient combination for us.

The impression that visitors get on visiting an engineering school is largely determined by the standard of housekeeping that they observe. I have visited many engineering schools where the impression left was similar to that which one gets from visiting a junk yard. In our instruction certainly we should inculcate standards of order, neatness, and cleanliness and that brings us to the question of housekeeping which always is a headache and a disagreeable task. It is something that cannot be left to chance as most human beings, including even some of the best instructors, are not naturally neat and orderly. We have tried to follow two simple rules in this connection. One is "see that things are put back in their regular places" and second, "leave the premises cleaner than you found them." I do not say that these rules always work but at least they are good rules and life would be simpler and more pleasant for all of us if everyone would follow them.

Professional Development of Staff

I should not like to close this discussion without some reference to the professional development of the staff. Any good instructor will improve his teaching with experience but that is hardly enough. Growth and development of a

department come largely as a by-product from the extra things that staff members do over and above their routine work. A sermon could be preached on this subject alone but let's let it go at that. From the personal standpoint, staff members should make use of the opportunity to grow professionally by such means as activity in at least one professional society. We now have student branches of ASME, SAE, IAS, and ASHVE, and I am sure that the staff members who serve as advisers for these organizations are the better for it. Membership in the professional societies and activity in engineering registration is worth far more than it costs, and the man who says that he cannot afford to belong to a professional society is very shortsighted indeed.

Of course a department can hardly be expected to finance very many trips, particularly all the way East, for staff members to attend meetings since budget allowances for travel are never sufficient. Most of the societies named have local sections and attendance at such meetings is not too great a burden. Certainly every engineering instructor should belong to ASEE and take part in at least any meeting of the Society at his own institution or nearby, for he is an educator as well as an engineer.

Qualifications of Chemical Engineers for Industrial Research[1]

By R. M. BURNS

Bell Telephone Laboratories, Inc., Murray Hill, N. J.

A survey of the occupational status of professional chemical engineers has shown that nearly a third are engaged in applied research and development work in industry.[2] Since it may be assumed that a similar proportion of the coming generation of chemical engineers will be employed likewise, it is a matter of some importance that those qualities of mind and traits of character essential to successful engineering research careers be recognized and examined. Before proceeding to the consideration of these qualifications, it will be well to discuss the meaning of the terms research, engineering and chemical engineering.

Definitions

"Basic scientific research" succinctly stated[3] "deals with the establishment of fundamental facts without particular reference to their usefulness. Engineering research, on the other hand, deals with the practical application of basic knowledge to useful purposes." Thus, engineering research is applied research and includes much that is ordinarily called development. The huge expenditures listed for research by industry are not spent on basic research but on development programs. "Research" is a term badly misused by industrialists. Scientific research contributes new knowledge of unpredictable importance whereas engineering research consists in effort toward a definite goal of practical importance.

Chemical engineering has to do with the conversion of raw materials into usable products through the mastery of industrial processes.[4] It has an important economic component in that cost, market conditions and time required to put into production may be critical factors. In its different aspects chemical engineering may vary from the predominantly chemical to the predominantly engineering and from laboratory development to plant design and process operation. In essence, chemical engineering is a state of mind, an engineering attitude or way of thinking about chemical reactions and materials. It is not necessarily a product of special training. This may explain why many chemists are able to become leaders in chemical engineering, for it appears that the engineering profession leans heavily upon chemistry for the production of its Ph.D's.[5]

Qualifications for Research

1. Training

It is scarcely necessary to say that the undergraduate course in chemical engineering should offer the fundamentals of

[1] Presented before the Chemical Engineering Division at the Annual Meeting of the A.S.E.E., Troy, N. Y., June 1949.

[2] A. Fraser, *Chem. and Engineering News*, **25**, 3068 (1947).

[3] "Engineering and Human Affairs." Princeton University Bicentennial Conferences, Series 1, Conference 3, page 21, 1946.

[4] W. L. McCabe, *Chemical Eng. Progress*, **45**, 87 (1949).

[5] Progress Report Number 19 of the Committee on Professional Training. *Chem. and Engineering News*, **27**, 415 (1949); A. Fraser, "Professional Chemical Engineering Pays Off." *Ibid.*, **25**, 3068 (1947).

chemistry, chemical engineering, thermodynamics, economics, mathematics through the calculus, some knowledge of mechanical and electrical engineering, not less than two years of English composition and courses in German, French and probably Russian. It is well recognized that training in fundamental principles is more important than detailed instruction in specific manufacturing processes.

Graduate training at the doctorate level is highly desirable, if not necessary, for men who are to do independent research in chemical engineering. This training, in addition to pertinent advanced course work, should place special emphasis upon the methods and practice of research. The doctoral thesis does not provide sufficient experience in the conduct of research; fully a third of the graduate student's time should be devoted to minor researches on a variety of subjects preferably unrelated to his principal thesis.

One of the most difficult problems confronting the graduate schools is that of selecting for admittance to candidacy for the doctorate men of potential research capacity. A high standing in terms of grades is not a safe criterion for it may indicate only a good memory and a determination to make Tau Beta Pi. A few "B's" and even a "C" could be a good sign of a discriminating mind. While the task of detecting research talent should not devolve solely upon the graduate school, any doubt as to the fitness of individuals who seek the higher degree should be resolved by the end of the first year of graduate study. While capacity for research is largely a function of the qualities of the mind, a successful career in engineering research in industry may depend as well upon the possession of certain traits of character and acceptable social behavior.

2. Qualities of Mind

The most essential attribute for research is creative imagination or capacity for independent original thinking. This is probably an inherent and inherited character which requires proper environmental stimulation for its full development. It is fair to ask in what respect does this quality of mind differ in potential scientists and engineers. Is there an actual difference or is it a matter of degree, the scientists possessing the greater imaginative ability? There can be no doubt that differences in interest and in type of mind are involved. Scientists are interested in discovery, engineers in invention; scientists tend to deal with the abstract, engineers with the concrete. Scientists get satisfaction in the comprehension of relationships previously unknown[6] while engineers like to foresee practical signficance and useful applications. Both require common sense and uncommon ability.

The process of creative thinking is not clearly understood and appears to involve unconscious mental reactions in which numerous relationships and combinations are tried, leading eventually to the synthesis of a conscious idea. The incubation stage of the process is said to occur at a time when the thinker is experiencing his greatest frustration. The moment of insight is necessarily followed by a period devoted to verification and checking with reality.[7]

Now it would seem that engineering research with its definite objectives would require somewhat less sheer creative ability than basic research. Organized development programs are to a large extent guided tours in search of further information and demand less that is new. In basic research a sense of scientific beauty

[6] v. H. D. Arnold's definition of research in a lecture delivered at the Lowell Institute, Boston, Mass., January 5, 1932.

[7] Jacques Hadamard, "The Psychology of Invention in the Mathematical Field," Princeton University Press, Princeton, N. J., 1945.

E. D. Hutchinson, "How to Think Creatively," Abingdon-Cokesbury Press, New York, 1949.

may be the principal incentive in the intellectual adventure giving rise to a new idea. There is no doubt, however, that engineering research does require in its practitioners a considerable degree of originality. For one thing, talent in this direction will enable the engineer to understand better the scientist and to use his research methods in engineering development programs based upon the scientist's findings.

Objectivity, independence, reasonable scepticism and the ability to consider ideas on their merits alone are marks of the research type of mind. In contrast, inseparable association of ideas and ego, "credit-grabbing" and professional jealousy are indicative of small minds unsuited for research. A cardinal requirement in the conduct of research is rigorous intellectual honesty. The selection or suppression of data in the interest of a preconceived viewpoint, whether done deliberately or unconsciously, is an insurmountable barrier to achievement in research.

It is commonly held that clear thinking is a prerequisite to clarity of expression. Without doubt the ability to write clear and concise reports and to present data in simple and logical fashion before conferences is required of those engaged in engineering research.

Among other qualities to be expected in chemical engineers who go in for research are resourcefulness in the planning and execution of experimental work, great persistence toward the attainment of objectives and the courage to make decisions and take action in instances where action is required and complete information unavailable. He must recognize the necessity of a margin of ignorance as well as a margin of safety.

3. Traits of Character and Social Behavior

A characteristic feature of industrial research is group-effort in which teams of men composed often of specialists in related fields work together toward a common goal. Individual effort is the exception particularly in the larger organizations. This close association requires good human relations. Individuals composing the group must be able to get along together. Indeed personal characteristics and behavior are fully as important as technical ability in men who desire to enter industry.

Of foremost importance among personal qualities is good manners. Tactfulness, thoughtfulness and generosity toward others are important components of pleasing personalities. Social acceptability depends upon personal qualities.

4. Capacity for Development

Men do not become chemical engineers merely upon exposure to the college curriculum no matter how good their grades; they do not go far in research without the capacity to use in an increasing degree previously learned principles. Unless experience sharpens the wits and leads to growing power in independent thinking, notable achievement is unlikely. A characteristic of successful young men in engineering research is their active and sustained interest in their employer's business; his problems become their problems as they seek to apply inventive skills toward the development of new processes and new products. Both economic opportunity and technological feasibility stimulate the imagination of the research-minded engineer; he becomes capable of projecting himself beyond his immediate task and develops a broad view of chemical industry.

5. Capacity for Work

Educational advantages and high qualities of mind count for little unless the individual possess what may be called the capacity for work. Trite as it may sound, success requires hard work even of the gifted, and laziness is the greatest deterrent to achievement. Capacity for work is evidence of a disciplined and

orderly mind. After all, thinking is hardest kind of work, and for the population as a whole, doubtless the rarest.

In conclusion, it may be reiterated that talent for research is inborn and requires for its development favorable environmental stimulation; that chemical engineers to be useful in industrial research must have this talent as well as thorough training, certain favorable personal traits, ability to express themselves in the English language, to grow with experience, and above all the will and the capacity for hard work. Men so qualified come to be numbered among the country's most useful citizens.

Needs for Texts in Technical Terminal Courses in Junior Colleges

By JAMES W. REYNOLDS

Professor of Education, George Peabody College for Teachers

The procedure employed to study textbook needs involves securing the judgment of the instructors who are teaching technical terminal courses. While this approach has certain limitations, its frequency of use is sufficient to warrant acceptance of its results.

The colleges studied are, with one exception, located in the region served by the Southern Association of Colleges and Secondary Schools. Schools were selected on the basis of available college catalogues in the library of George Peabody College for Teachers. Technical terminal courses are considered primarily as courses intended to develop competence in the area of industrial vocations.

The following information was secured from the eighteen colleges selected: (1) vocations for which course offerings prepared the student, (2) textbooks used in the courses, (3) criticisms of the textbooks used, and (4) characteristics which should be possessed by a desirable textbook.

Certain limitations are inherent in a study based on the judgment of instructors. Among these are the following:

1. The judgment of instructors is likely to be influenced by events in the immediate past. Thus, if a particularly unsatisfactory experience has resulted from a portion of a certain text, this experience is liable to influence the instructor's judgment concerning the whole text.

2. Since many programs for aviation mechanics are based on CAA manuals, and reports on these manuals as texts have been satisfactory, little effort was made to study textbook usage in these courses.

3. No two colleges are emphasizing exactly the same objectives in their courses.

4. Some courses are offered by very few of the colleges in the sample, as, for example, Care of Shop Equipment was found as a separate course in only one college.

In the light of these limitations, the following is a summary of the responses from the selected colleges.

Twenty-two categories of courses were reported. These, in turn, break down into fifteen sub-classifications dealing with teaching vocational skills and information, and seven sub-classifications concerning related science. The fifteen sub-classifications include: aircraft repair, auto mechanics, blueprint reading, care of shop equipment, electricity, foundry, internal combustion engines, machine shop, mechanical drawing, pattern shop, radio, refrigeration, sheet metal, welding, and woodwork. The seven sub-classifications of related science include: chemistry, English, industrial relations, mathematics, metallurgy, physics, and social science. A total of ninety courses are included in these classifications.

An analysis of the comments made by the instructors of the courses suggests four levels of satisfaction with textbooks. These include the following: (1) the least satisfactory in which no acceptable text has been found, seven courses or

7.7 per cent of the ninety courses; (2) present text unsatisfactory, 25 courses or 27.5 per cent; (3) present text satisfactory with reservations, eight or 8.8 per cent; and (4) present text entirely satisfactory, 50 courses or 54.9 per cent. Based on the lowest levels of satisfaction, no satisfactory text found and present text unsatisfactory, it is seen that more than a third of the courses now offered in technical terminal programs have definite needs for texts.

The next phase of the analysis concerns the chief criticisms of texts now in use. In this connection, it is well to recall the possibility that the text in use may be satisfactory to the person or persons who selected it, but does not measure up to the expectations of the instructor who is using it.

The specific causes for dissatisfaction are listed here in the order of their frequency of mention. Frequency of mention means the number of different courses for which the cause was mentioned.

Cause for dissatisfaction	Frequency of mention
Too little specific application to my field	12
Too general	8
Too few illustrations	6
Too difficult for average student	5
Overly technical for beginners	4
Too simple	2
Not sufficiently comprehensive	2
Illustrations are unsatisfactory	2

Fifteen other causes were mentioned only one time.

A few of the causes apply only in specific junior colleges, while a few others are stated so ambiguously as to be meaningless. On the whole, however, the list appears to be significant.

One generalization which emerges is that the specialized nature of vocational courses makes the preparation of a text sufficiently general for wide sales and yet sufficiently detailed for use in a specific course a most difficult problem. This generalization by the first three causes in the list.

This generalization is further borne out by two comments of a more general nature made in letters sent with the questionnaires. One junior college dean said, "The consensus of our instructors seems to be that many of the available textbooks can serve only as a skeletal outline, to be clothed with specific subject matter appropriate to this program." Another dean states, "In all cases we prefer to use textbooks but the subject matter is so specialized in our courses that this is practically impossible."

Course offerings in which the greatest dissatisfaction exists include: mechanical drawing, care of shop equipment, auto mechanics, machine shop, electricity, welding, English, and internal combustion engines.

A wide variety of texts are used in classes. In only one instance was a text found which was classified as unsatisfactory by more than one school, a text used in electricity. In another case, a text regarded as unsatisfactory by one instructor was approved by another. The approval was qualified, however, and the qualification made the two responses in virtual agreement.

An analysis was made of the relationship between the date the text was published and its status of acceptability. Publication dates ranged from 1922 to 1947. Over half the texts listed were published in 1945 or later. Only eight were published in 1939 or earlier. This analysis revealed no relationship. The four texts published in 1937 or earlier were considered satisfactory, while almost a fourth of those published in 1945 or later were regarded as unsatisfactory.

Seven of the ninety courses included in this study were being taught without textbooks. Instructors attributed this situation to the fact that no satisfactory text had been found, and pointed out that desirable textbooks should have the following characteristics:

1. Make specific application to the course.

2. Each topic should be sufficiently detailed.

3. Provide a list of references and other instructional aids.

4. Organized psychologically, proceeding from the known to the unknown.

5. Contain worksheets correlated with the text.

An examination of these five statements indicates that in outlining ideas for an acceptable textbook the instructors were reasoning from the same causes involved in deciding that currently used textbooks are unsatisfactory: the text is too general for use in a specific course.

Approximately one-third of the ninety courses considered are being taught with textbooks regarded as unsatisfactory, or without textbooks since no satisfactory one has been found. Thus, the textbook problem is sufficiently serious to warrant attention.

The chief cause for the dissatisfaction appears to lie in the fact that the unique character of each course makes textbooks of a more general nature unsatisfactory for the individual course. This would tend to assign the blame to the publishers of the textbooks.

A more comprehensive consideration, however, changes this conclusion. Textbook publishing is a highly competitive enterprise. While the publishers serve the market, yet publication demands sufficient sales to cover production costs and leave a margin of profit. This leads to the publication of texts that are sufficiently broad in their coverage to permit use in many situations. This factor is appreciated by the junior college instructors who gave no indication of blaming the publishers.

One possible remedy for the unsatisfactoriness of some of the available texts exists in the standardization of courses by junior colleges. This would make courses more uniform, and present to the publishers an opportunity for serving a less diverse market. Standardization, however, is contrary to a basic principle of curriculum organization; that each school reserves the right to organize its courses independently of external pressure.

The question of standardization, however, does not require an either/or answer. Automobile manufacturers have long since realized that they could retain the individuality of their products and at the same time utilize some degree of standardization of parts. The point has already been made that in courses for aircraft mechanics some standardization has occurred in line with the use of CAA manuals.

The following considerations seem practical as a means of solving the problem of textbooks in technical terminal courses.

1. The Southern Association of Junior Colleges organize a cooperative study of the technical terminal curriculums in the educational programs of member institutions to the end that:

a. Such voluntary standardization of courses as may seem feasible be accomplished.

b. Fields in which unsatisfactory textbook conditions exist be identified.

c. Results of this identification be made available to textbook publishers.

This method of approach to the problem should produce satisfactory results.

The Fine Arts in the Engineering Curriculum *

The time has come to ask the departments of humanistic-social studies to put their cards on the table. The makers of engineering curricula have a right to know what use will be made of the time allotted to those studies. It is not enough to say that engineers ought to "have" some acquaintance with literature, history, philosophy, music and art; it is necessary to say what it is they will get. It is also necessary to examine the methods by which in the inevitably short courses the students can be helped to get it. At the conference of the English and Humanities Division of the New England Section of the A.S.E.E. at New Haven, Connecticut, on October 8, 1949, the three papers addressed themselves to these questions as they arise in the teaching of painting and the graphic arts, of music, and of literature. Because the first two papers deal with the arts which are less common in the curriculum than literature is, it is thought that they will be of unique interest to the readers of the JOURNAL. Stefan Hirsch, a well-known American painter, is professor of art at Bard College, Annandale-on-Hudson, has taught at Bennington College and at the Art Student's League in New York, and has been a lecturer in American universities for the Arts Program of the Carnegie Foundation for the Advancement of Teaching. Klaus Liepman is director of music at Massachusetts Institute of Technology, and has introduced there a program of music education that is drawing the interest of increasing numbers of students as well as of engineering educators. The paper on Literature was read by Professor Cleanth Brooks of Yale University, one of the leaders in the re-vitalizing of the teaching of literature in American colleges. It is hoped that Professor Brooks' paper may be published in a future issue.

C. H. GRAY,
Chairman of the Conference,
Head, English Department,
Rensselaer Polytechnic Institute

* A Symposium: A.S.E.E., New England Section, New Haven, October 8, 1949.

The Growth of Statistics and Quality Control in Engineering Courses*

By JOHN A. HENRY

Associate Professor of Mechanical Engineering, University of Illinois

The writer has been an interested participant-observer of the impact of statistical quality control on engineering curricula. Five years ago this topic was knocking at the door in overalls, one of a number of courses sponsored for industrial personnel under ESMWT. In a very few colleges, quality control was offered as a credit-bearing course, and it had few takers.

What has happened in five years? For one thing, the American Society for Quality Control has sprung into existence. Its 2500 members are gathered from all corners of the industrial and academic worlds. By the very nature of its field, the membership is heavily weighted with men in the engineering management area, men who are keenly interested in the development of the rising generation of engineering students. These men want to know what is going on back on the campus. Many undergraduate and graduate students are also asking about the place of, and opportunities for, statistics and quality control in their programs. Engineering teachers and administrators have been seeking information.

As Chairman of the Subcommittee on College Courses of the ASQC, the writer has had the pleasant task of guiding a survey on the current status of these topics. A necessary, if hateful, questionnaire was sent to 162 engineering colleges. Sixty-five per cent were returned, covering seventy-six per cent of the 1948–49 senior class, as listed in the ASEE Year Book. Table 1 gives the results of the survey. It should be emphasized that these figures are approximations, and include as nearly as possible engineering students only.

The figures indicate that six times as many undergraduate students are taking statistics or quality control as were taking them three years ago. Even with allowance for changing enrollment, the increase is impressive. It is also notable that at least ten per cent of our graduate students now earn some credit in statistical methods. Five or even three years ago, that figure would have been close to zero.

At first glance, it seems impossible for a new field of study to invade the typical engineering curriculum. The never ending controversy over technical vs. liberal and professional vs. basic courses puts a premium on seniority. In at least two institutions, statistical methods have been dropped in favor of the humanities in the past few years. This, if it proves anything, proves that vested interests are more easily disposed of when far from the major field. Again, engineers and medical men have been noted for their indifference to statistical philosophy and techniques, depending on the evidence of absolute mathematics, on the evidence of overpowering but expensive experimen-

* Complete copies of the report "Statistics and Quality Control in Engineering Courses," from which this article was developed, can be obtained by writing to the Secretary of the American Society of Quality Control, 22 East 40th Street, New York 16, New York.

TABLE 1

NUMBERS ENROLLED IN COURSES

Number engineering colleges queried	162
Number engineering colleges replying	105
Seniors (1948–49) in 162 colleges (approx.)	45000
Seniors (1948–49) in 105 cooperating colleges	34450
Number colleges reporting courses in statistics	49
Number colleges reporting courses in quality control	35
Estimated engineers taking undergrad. statistics (1949)	2180
Estimated engineers taking undergrad. statistics (1946)	450
Estimated engineers taking undergrad. Q. C. (1949)	2050
Estimated engineers taking undergrad. Q. C. (1946)	244
Total number of graduate engineering degrees 1949	4500
Estimated number of engineering graduates taking courses in statistics and quality control 1949	560

tation, or on insufficient evidence that provides for little more than a hunch.

Against this formidable opposition, we find 49 engineering institutions making statistical techniques available for some or all of their students, and 35 offering courses in "quality control." Many more report imminent activation of those courses. It should be noted that quality control is in most instances nothing more than statistics, and rather basic statistics at that. Some mathematical statisticians feel that quality control is the ideal point of entrance to statistics for the non-math major.

Increasing Importance of Statistical Methods

Increasingly, engineering teachers and practitioners recognize statistics as a basic tool. It is concerned with the collection, presentation and interpretation of data as a basis for action. It is as basic as arithmetic, English or physics in physical investigations, and is invaluable in the allied fields of management, sales and psychology.

TABLE 2
WHERE COURSES ARE TAUGHT

Department Teaching	Undergraduate		Graduate
	Stat.	Q. C.	Stat. and Q. C.
Math. and Stat.	26	10	8
Commerce	14	3	4
Engineering	8	20	7
Other	1	2	2
	49	35	21

Table 2 shows how recent is this trend. In only 8 of the 49 institutions do engineering faculty participate in the presentation of formal statistics. The record is much better in quality control. It is hardly reasonable to expect that the teacher in commerce or even in mathematics can convey to the engineering student the full importance of statistics as applied to the scientific method in engineering. Yet the writer will venture a prophecy. Just as today industrial quality control threatens to dominate the field of mathematical and applied statistics, so tomorrow engineering education and practice will be a major factor in these fields. The aim, of course, is to make better engineers, not third-rate statisticians.

From where will the teaching personnel come? In part it will be the result of the reconversion of present-day teachers in conventional fields, but the majority will be developed by institutions now offering courses at the elementary and advanced levels, a never ending, irresistible chain reaction.

An Outline of Thermodynamics

By M. G. GLEASON

Pennsylvania State College

Thermodynamics is concerned in particular with the transformation of heat into other forms of energy, and, among the natural sciences it probably stands apart by reason of its almost universal application. For example, it serves the physicist in striking an energy balance, it predicts the direction of chemical reaction for the chemist, and it is indispensable to the engineer in a study of heat power.

Throughout the literature on this subject, it is of special interest to observe the part played by the calculus in its development. Our purpose then is one of exploring a few of the simple mathematical devices that are considered essential to an orderly discussion of thermodynamics.

Equation of State

A system may be defined as a region of objective space which is bounded by some continuous surface and which contains all that is of immediate interest to a discussion. The properties of a thermodynamic system, which might be compared to the variables of mathematics, are said to define the state of the system. Thus, properties such as pressure, volume, and temperature are not unrelated quantities but are connected by a relationship:

$$F(P, V, T) = 0, \qquad (1)$$

which is called a characteristic equation of state. Hence, any one of the three variables may be expressed as a function of the other two by solving with respect to the given variable. For example, we may set

$$P = P(T, V).$$

If we now differentiate this last expression by means of the theory of partial differentiation,[1] then

$$dP = \frac{\partial P}{\partial T}\,dT + \frac{\partial P}{\partial V}\,dV. \qquad (2)$$

Should we desire to show explicitly which variables are held constant during this operation, we write

$$dP = \left(\frac{\partial P}{\partial T}\right)_V dT + \left(\frac{\partial P}{\partial V}\right)_T dV.$$

Similarly, when $V = V(T, P)$ or $T = T(P, V)$, the differential equations are written,

$$dV = \left(\frac{\partial V}{\partial T}\right)_P dT + \left(\frac{\partial V}{\partial P}\right)_T dP,$$

and,

$$dT = \left(\frac{\partial T}{\partial P}\right)_V dP + \left(\frac{\partial T}{\partial V}\right)_P dV.$$

Work and Line Integrals

When a system undergoes a transformation from one state to another, we sometimes refer to the transformation as a process. Transformations in which the final state of a system coincides with the initial state are called cycles. Further, if a system does external work on its environment during a transformation, the work is defined as positive work, but when the surroundings do work on the system, the work is said to be negative.

Let us consider a substance that is restrained in a cylinder by a movable

[1] "Advanced Calculus," W. F. Osgood, pp. 110–114, 1933, Macmillan Co.

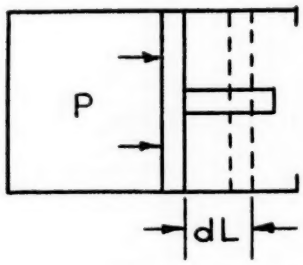

FIG. 1. Piston and cylinder.

piston, which has a cross-sectional area equal to A, as in Fig. 1. If the pressure, P, on the face of the piston is permitted to move the piston outward by an infinitesimal distance, dL, an infinitesimal quantity of work, dW, is performed by the system:

$$dW = PAdL,$$

where the product, PA, represents the force exerted on the piston. But AdL is an increment of volume, dV, and we write

$$dW = PdV. \tag{3}$$

Hence, for a finite displacement of the piston through an interval V_0 to V, a summation of the infinitesimal dW's leads to the definite integral,

$$W = \int_{V_0}^{V} PdV. \tag{4}$$

Now let it be assumed that the above transformation is reversible and that it satisfies the definition of a cycle. Since this particular transformation involves pressure and volume only, it can be expressed graphically in terms of P–V coordinates. Draw any curve C in the P–V plane, as in Fig. 2, to denote the cycle, and let C bound a plane region having an area A. Erect the tangent lines $V = V_0$ and $V = V$.

By definition, a line integral[2] $\int PdV$ taken from V_0 to V along path I gives the magnitude of the area under that portion of the curve. Likewise, the integral from V to V_0 along path II yields the area between the abscissa and the lower segment of the curve, but with a negative sign since dV is negative throughout. Hence, the algebraic sum of the two areas is equal to the area with the boundry C:

$$A = \int_{I} {}_{V_0}^{V} PdV + \int_{II} {}_{V}^{V_0} PdV = \int_C PdV. \tag{5}$$

But the integrand of (5) is identical with that of (4). Therefore, we conclude that the work done by the cycle appears as the area of a closed region in the P–V plane. It follows that

$$W = \int_C PdV, \tag{6}$$

where the integral (6) can be evaluated by expressing P in terms of V by means of the equation of path C.

This argument illustrates an application of the line integral in a form which is extremely practical, for herein lies the principle of the indicator mechanism.

Since the foregoing discussion has placed no restrictions on P, V, and T, except that they satisfy equation (1), let it be supposed that P, as a function of the other two variables, describes an arbitrary thermodynamic surface such

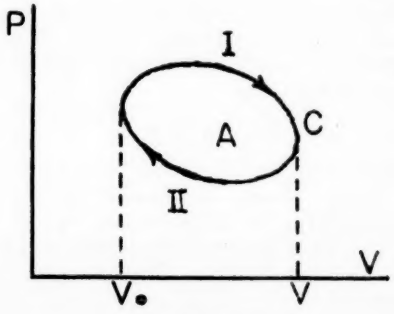

FIG. 2. P–V diagram.

[2] A line inegral, *e.g.*, $\int_C f(x,y)dx$, is the limit of a sum, and has a value that depends in general not only on the function being integrated but also on the path C of integration.

as that shown in Fig. 3. Now if P is held fast at some predetermined value, and the volume and temperature allowed to vary within certain limits, then each value of T and V defines a point of a plane region S bounded by the curve C.

In particular, we wish to inquire about the differential expression (2),

$$dP = \frac{\partial P}{\partial T}\,dT + \frac{\partial P}{\partial V}\,dV,$$

throughout the region S of the T–V plane. Under the given conditions the member on the left vanishes, *i.e.*, $dP = 0$, and the right-hand member lends itself to a treatment by Green's Theorem in two dimensions.

Let X and Y be two functions of (T, V), which are continuous, together with their first partial derivatives, $\partial X/\partial V$ and $\partial Y/\partial T$, within and on the boundary of the region S. The following identity will then exist:

$$\int\int_S \left(\frac{\partial X}{\partial V} - \frac{\partial Y}{\partial T}\right) dT dV = -\int_C X dT + Y dV.$$

By hypothesis, the double integral vanishes when extended over the region S; hence, we infer that the line integral on the right has the value of zero around C or any other closed path within the region. Furthermore, it can be argued that the line integral has the same value between any two points within the region, regardless of the path of integration, provided that the region is simply connected. These last remarks may be stated more precisely by means of two corollaries to the principal theorem.

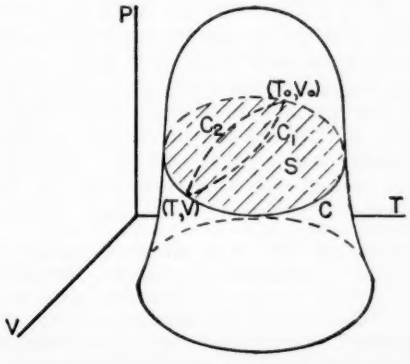

FIG. 3. Thermodynamic surface.

I. If X and Y, and their first partial derivatives, are continuous in a simply connected region, the necessary and sufficient condition that the integral

$$\int X dT + Y dV$$

should be zero around a closed path, and independent of the path connecting two points (T_0, V_0) and (T, V), is

$$\frac{\partial X}{\partial V} = \frac{\partial Y}{\partial T}. \qquad (7)$$

II. If the integral

$$\int X dT + Y dV$$

has the same value $P(T, V)$ for all paths connecting (T_0, V_0) and (T, V), the derivatives of P exist and have the values

$$\frac{\partial P}{\partial T} = X, \qquad \frac{\partial P}{\partial V} = Y.$$

It follows that true properties of a thermodynamic system are related by those functions which satisfy condition (7). More precisely, properties are said to be functions of state alone.

The Integrating Factor

In the preceding section we established the conditions for an exact differential equation and showed that equation (2) is of that form. We now inquire about a more general case. Consider a new expression

$$M dT + N dV = 0, \qquad (8)$$

where $M(T, V)$ and $N(T, V)$ are continuous, together with their partial derivatives $\partial M/\partial V$ and $\partial N/\partial T$, throughout a region S of the T–V plane. In general the expression will not be a

differential of any function $F(T, V)$, since $\partial M/\partial V$ and $\partial N/\partial T$ are not necessarily equal. However, (8) may become an exact differential when multiplied by a suitable factor $H = H(T, V)$, such that

$$dF = HMdT + HNdV; \qquad (9)$$

which is to say,

$$\frac{\partial F}{\partial T}dT + \frac{\partial F}{\partial V}dV = HMdT + HNdV.$$

Therefore, if the function $F(T, V)$ exists, it is a necessary and sufficient condition that

$$\partial F/\partial T = HM, \qquad \partial F/\partial V = HN.$$

According to the theory of differential equations,

$$\frac{dV}{dT} = -\frac{M}{N}, \qquad (10)$$

always has a solution of the form

$$F(T, V) = C;$$

where C is an arbitrary constant defining a one-parameter family of curves in the region S of the T–V plane. By definition, the slope of a particular curve at any point (T, V) is

$$\frac{dV}{dT} = -\frac{\partial F/\partial T}{\partial F/\partial V}.$$

But dV/dT is given by (10). Whence

$$-\frac{M}{N} = -\frac{\partial F/\partial T}{\partial F/\partial V}.$$

If we let $\partial F/\partial T = HM$ above, it follows by transposing terms that $\partial F/\partial V = HN$, which completes the proof.

The function H is called an integrating factor. It can be shown that such a factor always exists, and, is one that bears the utmost importance to the subject at hand.

The Energy Equation

The first law of thermodynamics is an extension of the principle of the conservation of energy to a special case involving heat and work. As such, any change of energy within a thermodynamic system must be equal to a corresponding variation of energy in its surroundings. In order to give this idea mathematical expression, it is convenient to accept the kinetic theory of matter and to confine the discussion in the beginning to a purely mechanical system. The ideal gas lends itself as the most suitable working substance, although any solid, liquid or gaseous substance could be used, provided that we carefully noted the peculiar physical properties of each.

For example, let us place the working substance in a thermally insulated cylinder similar to that of Fig. 1. This provides an isolated system in which an exchange of energy between the inside and outside can occur only in the form of work. Further, by reason of the kinetic theory, we assume that a certain amount of energy is inherent to the system, which may be denoted by U at some arbitrary level. If the surroundings are now allowed to do work on the gas by moving the piston inward, the energy will vary by an increment ΔU.[3] Equating this to the work done, we obtain

$$\Delta U = -W, \qquad (11)$$

where it will be noted that both terms are dependent only on the initial and final states of the transformation and not on the particular way in which it was performed.

From (11),

$$0 = \Delta U + W. \qquad (12)$$

If we next remove the insulation from the cylinder, the system becomes free to absorb energy in the form of heat, and is no longer isolated or purely mechanical. Under the new condition, the left-hand side of (12) will not in general be zero because the energy exchange between the system and its surroundings will in general be different from zero. There-

[3] In the case of a substance having a negative coefficient of volume expansion, ΔU would become a decrement, since $\Delta T = TVB\Delta P/C_p$ for an adiabatic change of pressure, where B is the average coefficient of volume expansion, and C_p is the average heat capacity at constant pressure.

fore, let us represent the exchange of energy in the form of heat, during a finite process, by Q. The energy equation will then appear as

$$Q = \Delta U + W, \tag{13}$$

or by rearranging terms,

$$\Delta U = Q - W.$$

It follows that ΔU represents the total amount of energy absorbed by the system from its surroundings, while Q represents the energy absorbed in some form other than work. Hence, an instantaneous value of U depends only on the state of the system, but Q and W are quantities which depend strictly on the process involved, a fact which has been abundantly proved by experimental evidence.

For an infinitesimal reversible process (13) takes the form

$$dQ = dU + dW. \tag{14}$$

But from (3) we know that $dW = PdV$. Whence, for a simple chemical system,

$$dQ = dU + PdV.^{4} \tag{15}$$

However, it is in (14) that we find a general mathematical expression for the first law of thermodynamics.

Let us inquire further about dU. If we consider U as a function of T and V, then

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV. \tag{16}$$

But by definition, the energy of an ideal gas depends only on its temperature. Therefore, the extreme right-hand member of (16) disappears, and we have

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT.^{5} \tag{17}$$

[4] For a discussion of other thermodynamic systems, see "Heat and Thermodynamics," M. W. Zemansky, Chap. 2 and 3, 1943, McGraw-Hill.

[5] For applications of the first law, see "Thermodynamics and the Free Energy of Chemical Substances," G. N. Lewis and M. Randall, pp. 62–70, 1923, McGraw-Hill.

The Entropy

A study of thermodynamics would be simple indeed if dQ of the energy equation were an exact differential, but since dQ refuses to comply with our wishes we are obliged to accept it as it stands. However, it can be shown how dQ may become exact by changing its character somewhat, and thus derive another thermodynamic property.

Proceeding on this premise, equations (15) and (16) yield

$$dQ = \frac{\partial U}{\partial T} dT + \left(\frac{\partial U}{\partial V} + P\right) dV.$$

It follows that

$$dQ = MdT + NdV, \tag{18}$$

where

$$M = \frac{\partial U}{\partial T}, \quad \text{and} \quad N = \frac{\partial U}{\partial V} + P.$$

By mathematics, it is evident that dQ is not exact since condition (7) requires that

$$\frac{\partial M}{\partial V} - \frac{\partial N}{\partial T} = 0;$$

but here,

$$\frac{\partial M}{\partial V} - \frac{\partial N}{\partial T} = \frac{\partial P}{\partial T}.$$

However, from our remarks about the integrating factor above, it is conceivable that (18) may become an exact differential when multiplied by a suitable function. Here, we may set the function H of equation (9) equal to the reciprocal of the absolute temperature and derive an equation that does satisfy condition (7), namely,

$$dS = \frac{dQ}{T} = \frac{MdT + NdV}{T}. \tag{19}$$

Thus, for an ideal gas, obeying the law

$$PV = RT,$$

an identity exists in the form:

$$\frac{\partial}{\partial V}\left(\frac{1}{T}\frac{\partial U}{\partial T}\right)=\frac{\partial}{\partial T}\left(\frac{1}{T}\left(\frac{\partial U}{\partial V}+P\right)\right),$$

$$\frac{1}{T}\frac{\partial^2 U}{\partial V\partial T}=\frac{\dfrac{\partial^2 U}{\partial T\partial V}+\dfrac{\partial P}{\partial T}-\dfrac{\partial U}{\partial V}+P}{T}-\frac{P}{T^2},$$

$$=\frac{1}{T}\frac{\partial^2 U}{\partial T\partial V}+\frac{T\dfrac{\partial P}{\partial T}-\dfrac{\partial U}{\partial V}-P}{T^2},$$

$$=\frac{1}{T}\frac{\partial^2 U}{\partial T\partial V}+\frac{\dfrac{RT}{V}-0-\dfrac{RT}{V}}{T^2},$$

$$=\frac{1}{T}\frac{\partial^2 U}{\partial T\partial V},$$

$$\frac{\partial^2 U}{\partial V\partial T}=\frac{\partial^2 U}{\partial T\partial V}.$$[6]

Therefore,

$$\frac{\partial}{\partial V}\left(\frac{M}{T}\right)=\frac{\partial^2 U}{\partial V\partial T}=\frac{\partial}{\partial T}\left(\frac{N}{T}\right),$$

which completes the proof.

From our earlier discussion of Green's Theorem, it is reasonable to assume that the integral,

$$\int\frac{MdT+NdV}{T},$$

has the same value for any path connecting the point (T_0, V_0) with an arbitrary point (T, V), and has the value of zero when extended around a closed path in the T–V plane. Thus it defines a new property among the thermodynamic coordinates—namely, the entropy of the system.

By integrating equation (19), the entropy function may be expressed as,

$$S=\int_{(T_0,V_0)}^{(T,V)}\frac{dQ}{T}$$

$$=\int_{(T_0,V_0)}^{(T,V)}\frac{MdT+NdV}{T}+\text{Constant},$$

where the absolute value of S is undetermined since an additive constant is always present. However, a variation of entropy between two states is readily calculated by assigning some arbitrary value to the constant, for example S_0.[7]

Since we have shown $\int dQ/T$ to be independent of the path, we need only concern ourselves with the initial and final states of equilibrium of any process whatsoever. This circumstance is most convenient because it permits us to substitute some reversible process at pleasure for any irreversible process whose path is obscure, and arrive at the same entropy change for the system in either case. It is on the strength of this principle that the entropy tables for thermodynamic calculations are constructed.

Finally, on the basis of the Carnot Cycle and the Clausius Theorem, we find it reasonable to conclude that the entropy function was conceived solely to give mathematical expression to the second law of thermodynamics.

[6] For applications of the second law to homogeneous systems, see "Treatise on Thermodynamics," M. Planck, pp. 119–131, 1921, Longmans Green & Co., London.

[7] Fermi shows that it is possible to calculate the absolute value of the entropy at any temperature by applying statistical methods or the Nernst Theorem. Hence, the integration constant is indeterminate only in the sense of elementary mathematics. "Thermodynamics," E. Fermi, pp. 139–155, 1937, Prentice-Hall.

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What Does Industry Want from the Junior College?[1]

By LELAND L. MEDSKER

Dean, Wright Junior College

The subject assigned to me today is presumably as broad or as narrow as one wants to make it. Although it would be interesting to deal with the subject from a national point of view, and certainly the many studies that have been made concerning the need for semi-professional workers and the responsibility of the junior college for training them indicate no lack of data for consideration at the national level, it will perhaps be more profitable and interesting to limit our thinking to a specific local situation. As we do this, however, it will be impossible to divorce entirely our thinking on national trends or to omit reference to other studies which supplement our own.

It is only natural to assume that an institution such as ours would have faced long ago the problem of its responsibility for technical education (technical education as used here will mean education of a scientific and engineering related nature). Although it is not the purpose of this paper to treat the matter of *pre-engineering* education, it, too, has been a concern of the institution. In fact, both phases of engineering and related education have been the concern of the college since its organization in 1934 and also by its predecessor, Crane Junior College, which existed in Chicago for many years prior to 1934. It has been in the last ten years, however, that increasing attention has been given to the problem of a curriculum of a terminal nature—a problem with many facets including such ones as the needs of industry, the contents of a terminal course, and the method of working with industry in the implementation of any training program. Although it might seem that the problems of the transfer and of terminal curriculum would be separate and distinct, experience does not indicate this to be the case because always there is the question with reference to the actual distinction between the two and of how they may be brought closer together. These and related problems have confronted us. Our attempts to solve them are not unique nor are they infallible. We have no panacea for all ills in this area of education. We can only report that we are trying to find out what industry would have us do and to do something about it.

Solution of Problem

Having identified the problem, we may now indicate some of the steps and procedures used in our attempt to solve it. Reference will be made to two attempts to look at the problem in a concentrated fashion. One was a study originated in 1937 when the speaker was assigned the general problem of determining the need for and content of courses of an occupational nature for all three branches of the city college. At that time and in subsequent years a continuous relationship was set up and carried on by representatives of the college with various key industries and with professional associations such as The Western Society of Engineers, The Chicago Section of the American Chemical Society, and similar organiza-

[1] Presented before the Junior College Division of the A.S.E.E., at the 57th Annual Meeting, Troy, N. Y., June 23, 1949.

tions. While no city wide, overall survey was made to get specific data, many months of continued conferences were carried on for the purpose of trying to identify just what it is that industry wants from students coming out of the junior college and going directly to work. We heard then, as we hear now, the story of good general backgrounds, ability to get along with other people, an overall knowledge of industrial processes, and certain specific abilities such as the testing of materials, etc. After several months of work and of give and take, a curriculum was set up in the college which at that time had the official approval of a number of trade and professional associations in the city.

Three curriculums were set up in the catalog of the college. One was a two year curriculum for technicians in chemistry, another was a two year curriculum for general technicians in engineering, and the third was a two year curriculum for technicians in engineering with an emphasis on drafting. Inasmuch as the people in industry and in the professions had told us that general education was important, approximately half of the required two year curriculum in each case was made up of our usual requirement of general education including a year of English, a year of General Social Science, a year of Biological Science, and a year of Humanities. Certain exemptions were made in the usual requirements of Physical Science due to the fact that the student was completing in each case a considerable amount of work in that area.

It can be said that in the case of the curriculum for chemistry technicians no special chemistry courses were created. Instead, a regrouping of offerings so that a student would have at least three semesters of regular college chemistry with an option of the chemistry of materials as a substitute for organic chemistry in the last semester. The chemistry courses were supplemented by engineering drawing and physics. In the case of the technicians in the engineering program, certain applied courses having to do with the testing of materials, the methods used in production, a study of mechanical machinery, and the study of hydraulic and electrical machinery were organized.

This curriculum, although quite carefully planned, really did not have a good test. No sooner did we get it in full operation than defense and war activities emerged to deplete the junior college of students who normally would pursue such a program. As most of you so well know, the veterans who returned, considered themselves, for the most part, pre-engineering students and thus, even with our large enrollment in 1946–47, we did not have many students whom we could interest in a terminal engineering program. It was in 1948 that we decided to re-examine the curriculum that we had set up previously and which had been on a more or less city-wide basis. This time we decided to make a survey of the industries in the neighborhood of our particular city college branch with the thought of localizing the demands to a greater extent than had been done several years ago.

Industrial Survey

Accordingly, a sampling was made of the firms in northwest Chicago. The sampling was confined to three groups sizes of industrial establishments. A total of eighteen of the industrial establishments was polled. Nine such industries employed more than one thousand people, six employed between 500 and 1000 and three averaged 250 employees. A faculty member with an engineering background from the Department of Physical Science was released to spend a considerable part of one semester in working with the various plant representatives and in spending time at the plants to secure information in the following areas.

1. Nature of production methods.
   (a) Types of unit processes
   (b) Methods of fabrication
   (c) Types of assembly
   (d) Nature of foreman control and supervision

2. Number of employees.
   (a) Skilled
   (b) Semi-skilled
   (c) Unskilled
   (d) Number and type in various wage brackets (if possible)

3. Skilled and semi-skilled requirements.
   (a) General and technical background desired
   (b) What aptitudes

4. Selection of skilled and semi-skilled workers.
   (a) How chosen for various operations
   (b) What initial job would a trained man receive
   (c) What position do they occupy within the process

5. Requirements for promotion consideration.
   (a) Personality
   (b) Interests
   (c) Writing and expression
   (d) Organizational abilities
   (e) Technical skill as a product of both formal training and specialized training within the process
   (f) Other skills not directly connected with the process but of background value
   (g) Company and union seniority requirements

6. Subjects and material needed in a two-year terminal course to prepare men for a long range industrial promotion program plus any other views the interviewed may hold. This included a discussion of placement possibilities in part time and full time positions.

You will not be interested in all the details of the study and, in fact, I have not briefed myself on all of them. In many respects the nature of the study was somewhat objective in that the Director of it did not employ great sheaves of questionnaires and check-lists, but instead spent as much time as possible with various types of plant personnel. After a preliminary report was compiled, it was checked with the people with whom he had worked and then was considered by an advisory committee appointed from representatives of the industries involved.

Summary of Results

We shall summarize here only a few of the highlights found in the results of the study. In the first place, some interesting information was compiled regarding current industrial process techniques. Most of such information is well known by you and much of it we knew although the confirmation of it was all important to our faculty. The fact that process operations are becoming well simplified through the assembly technique was naturally stressed. That the assembly process requires the main bulk of workers who can obtain the necessary training on the job in from one to six weeks was a concomitant of the information regarding the processes. We were told, too, that the supply of technical production personnel has now reached an adequate status; that higher educational institutions supply adequate numbers of control engineers; that the trades supply all the skilled group of machinists, tool and die makers and electricians through apprenticeship training; that other skilled and highly rated semi-skilled positions are filled by the management system of upgrading and promotion selections. We were told that the personnel shortage is in the group that has the necessary background of technical and administrative knowledge to make low echelon supervisors and foremen. It was said that men in this group need three abilities:

1. The ability to detect assembly faults, report discrepancies, and suggest improvements in a group function.

2. The ability to control groups employed in a particular sub process and maintain a high standard of production incentive.

3. The knowledge and understanding necessary to advise and guide the men under them on problems within the

process and in their daily lives, thus maintaining a high degree of confidence and loyalty in the group.

More specifically, the employers said that general promotion requirements and qualifications for the lower echelon supervisor and foreman group lie along the following lines:

1. Seniority.
   (a) Total time employed by the firm
   (b) Total time within the department
2. Loyalty.
   (a) Attendance record during entire period of employment
   (b) Quality of work produced under specifications
   (c) Attitudes and cooperation of the individual during the entire period of employment
3. Background.
   (a) A broad and general background is desired
   (b) Competent technical ability and comprehension of the processes and production problems involved
   (c) Understanding and technical knowledge in any other industry is important because of the similarity of general patterns of production
4. Ambition and attitude.
   (a) Accomplishment and enterprise displayed on the job
   (b) Eagerness to learn the job and its related parts
   (c) Attendance at night school and company training meetings
5. Personality.
   (a) Willingness to accept responsibility and extra problems
   (b) Ability to receive and issue orders efficiently and in a friendly vein
   (c) Friendliness and interest in the job and the fellow workers
   (d) Appreciation of others' problems as well as your own

Training Program

In response to our questioning relative to the type of training program in a junior college that would supply workers with the necessary technical and general knowledge to make good promotional materials in line with the above-mentioned students, we were given rather consistent opinions in the following three areas:

1. General Education,

Employers indicated that they were actually more interested in the men as men than they were in specific training. Their opinions varied on the amount of curriculum that should be devoted to General Education. All of them indicated that at least 40% of the total curriculum should be general in nature and some suggested that the percentage might be as high as 70. There was general stress on English and social studies. There was continuous emphasis on Psychology, presumably because employers have a notion that Psychology, as such, enables employees to understand and direct others with a minimum of antagonism and ill will.

2. Guidance.

Practically all employers were in favor of a rigorous vocational counseling service. They made the following points:

1. Through counseling and orientation lectures, adult aptitudes and responsibilities should be impressed on the students. Part of this study should assist students to adjust to their environments. Emphasis should be tional characteristics and social behavior.
2. Industry should be studied to acquaint the student with the available possibilities, their advantages and disadvantages. Orientation can then follow on the various positions available in the manufacturing processes including methods of attainment plus desirable and undesirable working conditions.
3. Men should realize the importance of good personality traits, the ability to

get along with others, and the requirements of an able administrator. This includes the ability to make sound decisions and to pass them along to others.

4. Students should receive an initial battery of tests early in their training to aid in evaluating their interests and abilities. These tests will also indicate the chances of success in various fields.

3. Specific Technical Training.

Company representatives did not indicate that there should not be any specific training. They did, however, make the following recommendations with respect to the type of training that is desired for the employees in question:

1. A technical background that is broad and general but built along simple lines. This would include basic chemistry and physics that could be applied to any of the fields with a minimum of specialization, and enough mathematics to solve simple problems in trigonometry and algebra.
2. Blueprint reading and an understanding of production systems. This includes the use of toools and machines in measurement and power control.
3. Training in business sufficient to understand simple material control systems, the principles of marketing and inventories and basic business mathematics.
4. A comprehensive coverage of labor law fundamentals, their development, and how they are applied in the industrial world today.

Future Plans

As a result of the survey we have organized a new curriculum which will be initiated next September, 1949. To some extent, this curriculum is a re-grouping of courses from our present offerings. Two new technical courses have been organized. One is a basic course in applied Organic and Inorganic Chemistry with an emphasis on the principles underlying technical laboratory control in industry and the nature of materials, foods, and metal alloys. This is a one-semester course with two lectures and one two-hour laboratory period per week and carries three credit hours. The other is an applied Physics course offered in the second year of the curriculum with a prerequisite of a year of college Physics. The applied Physics course will deal with the application of the basic principles and laws of Physics to problems of power transmission and mechanical theory in industry. Discussion will include the elements of safety engineering and fire prevention. It will include assembly systems, physics of basic processes and fundamentals of production control. In addition to the courses already mentioned, the curriculum will include a one-year course in General Applied Mathematics; our usual requirements in Social Science, Humanities; and Biological Science; Report Writing; Personnel Management; Psychology; and Industrial Techniques.

It remains to be seen, of course, how the curriculum will work out, how popular it will be among students, and how receptive employers will be with regard to it. We feel, however, that it meets as well as we can see at present the recommendations made by industry. In addition, we have set the course up in a fashion that there would appear to be a minimum amount of loss if a student, during the first semester, or even during the first year, decided to switch from a pre-engineering program to this particular program.

This last statement, of course, leads to a definite and serious problem in junior college education. If we dare hope that both professional schools and industry can increasingly come to a common understanding and recommendation regarding certain basic characteristics that technical workers at all levels need, our problem will be smiplified. So long, however, as industry stresses general education and professional engineering schools stress

specificity, our programs are far apart and severe penalties are increased when students try to transfer from one to the other. There is evidence, of course, that in the entire engineering field long-term trends are developing which give rise to the development of the worker as an individual with somewhat less emphasis upon his technical knowledge. The discussion given to five-year engineering programs, the emphasis on general studies as reported recently in such institutions as M.I.T., and the nation-wide movement toward core curriculums of general education in the lower divisions of many leading colleges and universities are just a few evidences of what is going on.

Surely, we are fast coming to the point where we cannot look at vocational programs and programs of general education as something separate and different. Surely, we cannot believe that specialized training will make the entire man. Certainly, there must be something of vocational value in our so-called general education courses.

Applications of Thevenin's Theorem to Direct Current Motor Analysis

By WALTER E. ROGERS

Assistant Professor of Electrical Engineering, University of Washington, Seattle 5, Wash.

The simplifications which result from the application of Thevenin's theorem to circuit theory have made this valuable tool almost indispensable. Its general acceptance has occurred quite recently, however, compared to the time at which our present methods of analyzing direct-current machines were devised. The theorem is usually introduced in first courses in electrical engineering, and it would seem desirable to use it occasionally in the study of direct-current machinery.

When Thevenin's theorem is used as an aid to the analysis of the effect of line-voltage regulation on the characteristics of direct-current motors, it yields not only the expected equivalent circuit, but an unexpected dividend in the concept of an equivalent motor operating at constant line-voltage, and with an additional compounding field. This equivalent motor concept gives a strengthened physical picture, in addition to that ever welcome result of reducing a moderately involved problem to one for which the solution is well known.

Thevenin's theorem may be applied to the portion of the circuit to the left of the armature terminals of Fig. 1, in which A. S. A. symbols have been used. The line regulation is represented as an equivalent line resistance R_L in series with a constant voltage V; the resistance of the shunt field circuit is represented by R_F; the total resistance of the internal armature circuit by R_A; the counter emf by E; and the armature and shunt field currents by I_A and I_F, respectively. The open circuit voltage appearing at the armature terminals in the equivalent circuit of Fig. 2 is

$$V_0 = V\left(1 - \frac{R_L}{R_F + R_L}\right).$$

The internal resistance of the equivalent generator is

$$R_S = \frac{R_L R_F}{R_F + R_L}.$$

The concept of the equivalent motor operating at constant line voltage, V_0, follows from the following line of reasoning: Armature current flowing through the resistance R_S results in a voltage drop of $R_S I_A$ at the terminals of the field. The resulting reduction in field current is $R_S I_A / R_F$, and the reduction in mmf of the shunt field is then $N_F R_S I_A / R_F$, where N_F is the number of turns on the shunt field. This is exactly equivalent to the reduction in mmf which would be produced by a differential compound field carrying the armature current, and with the number of turns given by

$$N_S = \frac{N_F R_S}{R_F} = \frac{N_F R_L}{R_L + R_F}.$$

Further, we may equate the internal resistance of the equivalent circuit of Fig. 2 to the resistance of this equivalent differential compound field. The resulting circuit of the equivalent differentially compounded motor operating at constant line voltage is shown in Fig. 3.

In almost any practical application, the resistance of the shunt field circuit is very

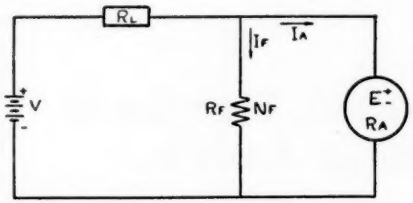

FIG. 1. A shunt motor circuit which simulates a varying supply voltage.

much greater than the resistance of the line, so that the internal resistance of the generator of the equivalent circuit is very nearly equal to the resistance of the line. In such a case, we are justified in saying, "The effect of the resistance of the line is simply equivalent to the introduction of a differential compound field. Its resistance is practically equal to the resistance of the line, and its magnetic effect can be very material."

The mmf of the equivalent differential compound field is by no means always negligible. For example, 5-hp., 125-volt, stabilized shunt motors frequently require an armature current of 40 amperes, and a shunt field current of 1 ampere. Such a machine with four poles may have about 6000 turns on the shunt field, and 6 turns on the cumulatively compounded stabilizing field. The equivalent line resistance accounting for a quite nominal voltage rise from full load to no load of 5 volts will result in the mmf of the equivalent differential compound field completely overcoming the mmf of the stabilizing field. The combined stabilizing effect of the stabilizing field and the equivalent differential field, when their mmfs are equal and opposite, is simply that of the added resistance of both placed in series with the armature.

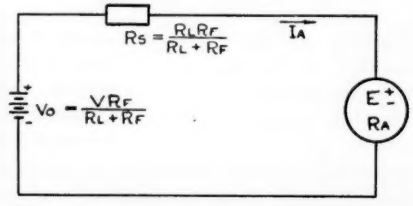

FIG. 2. The equivalent circuit of Fig. 1 after the application of Thevenin's theorem.

The line voltage regulation may not arise from the resistance of the line alone. It can arise from a short-shunt connection of the motor fields, or it can be the result of the armature circuit resistance of the generator. More than that, any reduction in excitation of the generator due to such effects as armature reaction or the compounding effect of the interpoles, or voltage regulation due to the speed regulation of the prime mover, may all be thought of as adding to the number of turns on the differential compound field of the equivalent motor. The not infrequently observed instabilities of shunt motors do not seem surprising when viewed in this light.

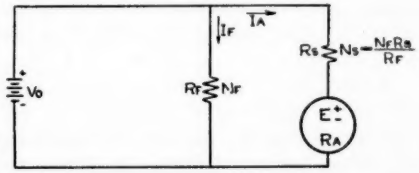

FIG. 3. The circuit of the equivalent motor which operates at constant line voltage and has a differential compound field.

This equivalent motor concept is not restricted to cases in which the regulation of the line is positive. We are at liberty to account for a rising voltage characteristic as due to the presence of a negative resistance in the line. Simply by changing the sign of R_L in the previous analysis, we are led again to an equivalent motor operating at a constant voltage. But now the polarity of the additional field is such that it is cumulative compounding. The resistance of the armature circuit is reduced by the internal resistance of the equivalent circuit. When the net effect of the reduction in armature resistance is greater than the increase in magnetization due to the equivalent cumulative field, we may expect a rising speed characteristic and its attendant instabilities.

The "bucking" or reversing motor is an illustration of the possibility that the total resistance in the armature circuit of the equivalent motor can become negative. The "bucking" motor is the term applied to that interesting laboratory demonstration in which a series generator with its sharply rising voltage characteristic is used to drive a separately-excited shunt motor. When the two are first connected the motor builds up in speed quite rapidly, drawing less current as its speed increases. When the counter emf of the shunt motor exceeds the generated voltage of the series generator, the armature currents of both machines reverse. The series generator rapidly builds up with the opposite polarity, which in turn brings the shunt motor to a stop, and the process is repeated in the reverse direction of rotation. When the motor is self-excited, the reversals of direction of rotation do not appear, but the speed fluctuates periodically over a wide range.

The Technical Institute in America, Its Background, Its Aims and Its Essential Characteristics

By ARTHUR L. WILLISTON

(Formerly) Director of School of Science and Technology, Pratt Institute, and Principal of Wentworth Institute

The American people, in spite of strong subcurrents of idealism, have always been a practical people; and from the earliest Colonial days—even from soon after the Pilgrims landing—our people have shown evidences of desire to train youths promptly according to their native talents for effectiveness in the practical activities of daily life.

To follow these evidences in detail would require a volume. The present purpose is only to sketch briefly certain tendencies in our National aims, to identify them here and there, to crystallize these aims so far as we are able, and to point out instances where they have developed and come to a conspicuous fruition and to cite other instances where they have, as it seems to me, sadly miscarried.

The first bit of evidence, within my own experience, of an effort to produce industrial intelligence and ideals of excellence in production among a selected group of young men—outstanding characteristics of the Technical Institute—occurred in Cambridge, Massachusetts, in the late 1870's. Equipment was provided by private individuals in the basement of a police station, an instructor was secured and evening classes were organized in various branches of woodworking. In order to help defray the expense of the enterprise, Saturday morning classes, too, were formed for boys, of whom I fortunately happened to be one, whose parents were able to pay a liberal tuition.

This early experiment later developed into the Rindge Manual Training School and today is continuing as a part of the Cambridge public school system under the name, I believe, of the Rindge Technical High School.

Calvin M. Woodward, Professor of Mechanics at Washington University, St. Louis, and President of this Society in 1902–03, was a pioneer in this field. And he was responsible for the establishment in St. Louis of a school much along the lines of the Cambridge School in its early days.

Another example of the type of effort that I am discussing was the introduction at about the same period, by Mrs. Quincy A. Shaw, of the Swedish system, in the Boston Sloyd School.

And a fourth example that might be mentioned was the beginning of the introduction of so-called shop practice into schools of engineering, stimulated by the display of the Russian System at the Philadelphia Exposition in 1875. At the start, this work had much of the spirit of these other examples that we have described; and they all possessed marked characteristics, as we shall later note, of the Technical Institutes of today.

Characteristics of Instruction

In all of these undertakings, at the time that I refer to, were certain important features—*first,* the instruction was largely individual; *second,* it was given in the main to persons who appeared to have probable capacity for industrial

leadership or efficiency; and *third*, the aim was toward creative industrial intelligence and knowledge of the then-current processes of industrial production in special fields.

On the other hand, as examples of this type of instruction multiplied and became general, as time went on, the spirit and aims changed and, it seems to me, they degenerated, as all pioneer effort is inclined to do, and the instruction became academic, stereotyped, and less vital.

In high school and elementary school, as manual training or practical arts instruction—while this may have gained certain other qualities of value—it became little more than another instrument, another subject in the curriculum, alike for all the pupils and with a common standard, for developing the same faculties and abilities sought by other departments of the school. The early aims were lost.

One notable exception to the above general rule of slipping from primary purpose to the level of standardized academic practice is the case of the Lane Technical High School, of Chicago, Illinois, under the principalship, from 1905 to 1924, of William J. Bogan. As long as the Lane School remained under his leadership, its pioneer purpose never wavered and it retained much of the true quality that we shall describe as the dominant features of the Technical Institute.

And, on the college level in schools or departments of engineering, the shop-practice soon lost all creative and inspirational value and became routine handicraft instruction devoid of insight into the marvels of American production.

I have taken your time and attention to describe in some detail, in these early examples, this tendency to change from a pioneer purpose—this tendency, as I believe, to slip and to retrograde from the high level of creative leadership to the level of the usual and the commonplace, because I wished especially to emphasize this persistent tendency for noble purpose to miscarry in the institutions more definitely recognizable at dates of their foundation as Technical Institutes. The list of those which have been lost to this field is a long one. The reasons that have led to the changes of purpose in these institutions have been various. Perhaps, however, the most frequent and compelling reason has been the ambition on the part of graduates and, in some instances, of faculty members, too, to have designations or titles attached to their names more closely resembling those appropriate for persons graduating from schools of higher learning.

Educational Philosophy

And now I wish to turn from these details of history to other aspects of the subject under discussion. The name "Technical Institute" was officially adopted at a Conference held in Rochester, N. Y., in 1922, at which there were representatives of Rochester Mechanics Institute, the Mechanics Institute of New York City, Ohio Mechanics Institute, Pratt Institute, Rankin Trade School of St. Louis, Cooper Union, Franklin Technical Institute of Boston, Wentworth Institute of Boston, and the American Council on Education of Washington, D. C.

The central *educational philosophy* underlying the methods and programs of these institutions was extremely simple:

A. The conviction that no two individuals are alike or have the same possibilities of growth and development; and, consequently, all instruction must be individual in character and adjusted to the needs of each individual student.
B. That by scientific procedure, trial and test, the special abilities or requirements needed for the most effective accomplishment in each occupational station or goal for student training can be discovered.
C. Only by tested educational methods can each student with his particular aptitudes and talents best be

guided toward his individual and desired goal.

D. And, likewise, by tested methods only can each individual best be encouraged to put forth his full effort for his own self-development.

Of course, this is nothing but plain commonsense! Yet it contradicts, turns upside down, and right-about-faces the usual—almost universally accepted—procedures of standardized education. It, however, obviously is the direct pathway to efficient, intensive instruction and education.

And, please don't assume the requirements of the goals referred to are measured only in practical tangible units. They may include all desired qualities of personality, historical background, knowledge of human values and creative imagination, all depending upon the individuals, the particular goals and the time that is available for the process.

Characteristics of Institutions

So much for the educational philosophy of the Technical Institute, and now let us consider some of the prominent observed characteristics to be found in the daily operation of the best of these institutions.

What are their notable features, by means of which they may be judged, and that distinguish them from other types of schools?

Over a long period of administration and of close observation, the following seem to me to be their outstanding traits. And, the extent to which these are discoverable in the regular practice of any school should determine the title of such a one to rightful classification as a member in the group of American Technical Institutes:

This is my list of distinctive traits:

1. The instruction centers upon the individual student.
2. The latent or potential talents and aptitudes of each student are sought and revealed.
3. Probable ultimate fitness for a calling or a specific type of job is made the chief criterion for admission to each course of instruction.
4. The instruction capitalizes each young man's ambition for particular achievement or for the attainment of some special goal.
5. Elements of the real work of the world are used as instruments of training.
6. Progress of pupils is appraised by visible and definite achievements.
7. The requirements are carefully adjusted to the abilities and capacities of each pupil.
8. Steps in the instruction or between assigned tasks are short enough to be readily mastered and to prevent confusion in thought.
9. Thus, speed and precision are encouraged.
10. New experiences are related to old in such a manner that the pupil draws valid conclusions and himself arrives at new principles.
11. Memory disciplines are subordinated to creative thinking and constructive action.
12. Throughout, a professional attitude is sought, sometimes expressed by the slogan, "A passion for superlative excellence and the consecration of one's trained talents in the service of mankind."
13. Conditions are created that foster those qualities of personality that result in leadership.
14. Habits are encouraged in both conduct and thinking that are helpful in meeting the requirements of future occupations.

Not every Technical Institute can meet the test of practising each and all of these fourteen specifications.

In Conclusion

Technical Institutes have been blessed by their freedom from restriction and hampering tradition and, in consequence, have been the more able to be guided by

the results of modern educational research. But the dearth of such schools in comparison with the need is little short of tragic.

America, increasingly, is an industrial nation. Apprenticeship has disappeared, and schools must be relied upon for our national efficiency. Colleges of Engineering, even if they were headed for the goal of industrial production, cannot fill the void. Short, intensive courses, broad enough to furnish vision and outlook, yet definitely efficient and practical, bridging the gap toward employment, are essential for the multitude.

In the place of one or two score of such schools in the United States, there should be at least one thousand scattered throughout the country furnishing training for fully half of the youth in our population. This obviously is the *missing link* in our educational system. Dr. Conant, of Harvard, has stated that post-high school students, in the main, profit most by two-year terminal courses, and reports that advanced education should be largely met by expansion in this area.

The opportunities for such expansion are many. These include not only the privately endowed schools and, under exceptionally favored circumstances, self-supporting commercial technical schools, but also state-supported two-year institutions on the level of the former two-year normal schools. There are also university-extension departments, evening schools of the type of the Westinghouse Graduate Schools, of Pittsburgh, extension of exceptional technical high-schools similar to Dr. Bogan's Lane High School, in Chicago, schools within industry like the one now operated by the General Motors Company and, lastly, the junior college.

But, of all of these, the phenomenal growth of the junior college in recent years in America furnishes the outstanding opportunity—indeed, a wonderful opportunity—for a genuine national service if only the organizers and directors of such institutions can see, or can be helped to see, the light. For, to fulfill this mission, it will be necessary for them to discard tradition and, in a truly pioneer spirit, follow with courage and with vision the commonsense philosophy and procedures that experience has demonstrated to be effective, as we have reiterated above. And, above all, they must resist the temptation to backslide into the slough of outworn tradition as has so often happened to educational effort in the past.

And, as a final word, I know of no nobler challenge that this Society could accept than the task of a genuine wholehearted crusade to broadcast the imperative need for extension of educational opportunities in this area, and the equally great need for adhering to sound philosophy and educational principle therein.

As a reward for such patriotic effort, it might happen, too, perhaps, that some of the members of this Society might also feel the urge and discover the way to bring the endeavors of their own institution more into line with modern educational thought.

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Drawing as a Training for Engineering

Drawing has been universally called the Language of Engineering. But all too frequently the distinction has not been made between drawing as a "Language" and "Making a Drawing."

The engineer must be a man of imagination—he must be able to think in space—to visualize. He must be able to visualize shape, size, material, operation, motion, weight, efficiency, and economy. This ability has its origin in a knowledge of the Language of Engineering. To learn any language one must of necessity learn the alphabet, idioms, expressions and be able to write or "compose." One must be able to read and to understand the language. This is just as true of the language of engineering as of any other language.

Drawing is a dual purpose language, important in itself as a basic subject but an absolute necessity for the real professional engineer. It provides a means of accurately checking space conceptions. Accurate drawings thoroughly understood lead to accurate thinking. They give practice in planning and developing methods of procedure. Every engineer realizes that planning and working out methods of procedure are necessary before undertaking any engineering work. Drawing constitutes such a factor in training for engineering. If this was truly understood and its importance realized, a great deal of time would be saved in the teaching and learning of other engineering subjects, for drawing is fundamental to all of them.

The making of drawings is related to the engineering language in the same way that writing is related to the everyday language. It is the ability to read and to think which is all important in both languages. The present day inclination in some quarters to minimize drawing comes from a lack of understanding and constitutes a real handicap in the training for engineering. A good foundation in the language of engineering is the key to success in training for engineering.

A certain amount of drafting experience is a most efficient and thorough means of learning and understanding an engineering project whether it is a single machine or a complete industrial plant. To make a real use of any subject one must have a sufficient knowledge of its possibilities for use. The time allotted to the study of drawing should be sufficient to allow it to be taught and learned as a language so that its real value can be brought out. Such time and effort will be more than repaid by a quicker grasp of the basic means of engineering thinking and a more efficient use of the developed ability to visualize engineering design and construction in connection with machines, equipment, processes, and all the vast number of ramifications of engineering in this industrial age.

No one NOW questions the value and necessity of English as a vital factor in engineering education but—it WAS NOT ALWAYS so. Drawing is going through a similar cycle which will only be remedied when the effects of cutting down on the time for drawing courses becomes evident in the practice of engineering as it did for English.

Without the ability to think clearly and well in the engineering language of drawing an engineering education is defective in the elements which are necessary to make it a truly professional education, with all that is implied in the word professional.

CARL L. SVENSEN,
Executive Secretary,
Texas State Board of Registration for Professional Engineers

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 14 & 15, 1950	D. M. Griffith, Bucknell University
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Michigan	Wayne University	May 20, 1950	H. M. Hess, Wayne University
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	Not yet determined	Oct. 3, 1950 Feb. 6, 1951	R. B. Allen, University of Maryland
New England	University of New Hampshire	Oct. 14, 1950	W. C. White, Northeastern University
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Virginia Polytechnic Institute	April 20, 21, & 22, 1950	H. G. Haynes, The Citadel
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13, & 14, 1950	F. H. Thomas, University of Buffalo

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WASSERMAN, BERNARD, Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. B. Doke.

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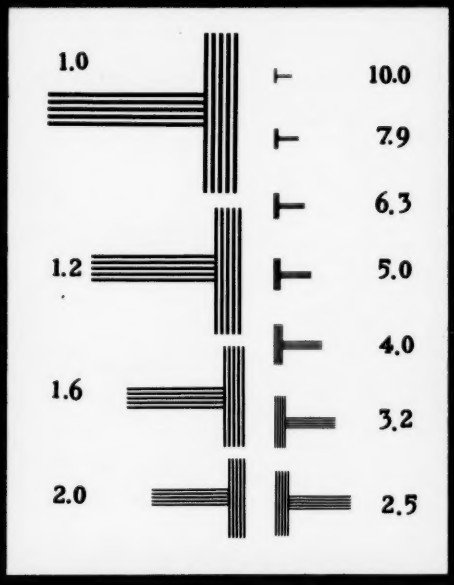
RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.

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